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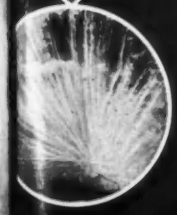

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Editorial:
Our Chemical Resources
Inside Front Cover

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Our Chemical Resources

➤ THE PROSPECT of enough of everything for all time to come, or of immediate shut-down of all our industries, can be deduced from papers given at almost any national meeting of scientists. Which is correct? Are some of the speakers misinformed, or is this the difference between optimist and pessimist?

Some shrug off the problem of vanishing resources by saying, "We are a wasteful people!" Some seek new sources of materials abroad. Some are investigating substitute materials. A few study better utilization of materials now in use.

The bare fact is that accidental deposits of certain materials all in one place have created many of our industries, and that the end of some of these deposits is in sight. This circumstance offers a challenge, and what we do about it will probably determine the future of our country for a long time to come.

The story of many an ancient civilization can be read by the geologist in the record of exploitation and depletion of mineral deposits. Present day world-wide searches for oil and iron and aluminum merely continue the Phoenicians' voyages for tin and the Spaniards' for gold.

Periodically throughout recorded history men group themselves into armies which make it their business to hurl their frantically-gathered metals and manufactured materials at each other. This dissipates resources which the forces of nature had spent millenia in bringing together. When they are gone there will be no more. Perhaps we have one chance left. If we can tame the forces within the atom and tame ourselves at the same time, we may today be seeing the beginning of a new era of peace and plenty. If we use our new-found respite merely to waste our resources on a larger scale, we are only accelerating our doom.

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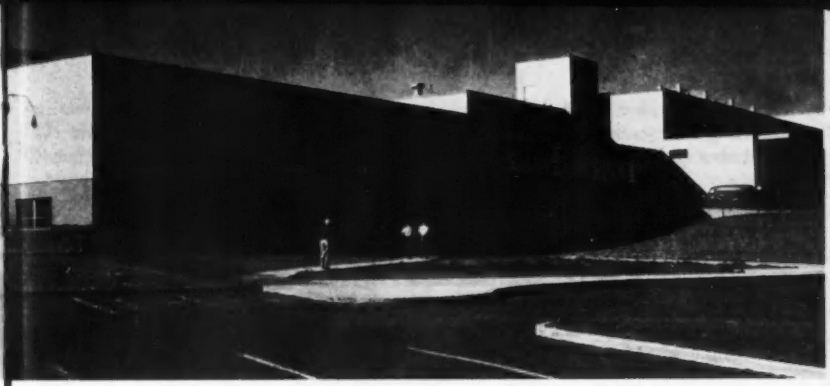

➤ HOT LAB *at Brookhaven National Laboratory, Upton, N.Y. is designed specifically for work with radioactive materials at high radiation levels. This new building is now ready to prepare and ship radioactive isotopes for research purposes.*

Atom-Bred Power

➤ ISOTOPES for peace and new kinds of atomic reactors for power are on the constructive side of current nuclear research. Several new developments emphasize the way scientists are getting on with the problem of living with atomic energy.

Radioisotopes from Brookhaven now supplement those which Oak Ridge has supplied for research during the past five years. Profiting by the experience of the older institution, the Brookhaven National Laboratory has just completed a new building for isotope production and "hot lab" research. The reactor at the Laboratory was rebuilt during the past summer, reaching the critical level in August 1950. Testing of various factors consumed several months before the reactor went into routine operation.

Other developments in the field of nuclear reactors were announced by the Atomic Energy Commission in its Ninth Semiannual Report just published. The Experimental Breeder Reactor in Idaho, which will try to breed new fuel faster than it is consumed, is under construction. Building of a land-based Submarine Thermal Reactor has been started at the same location, as well as a chemical processing plant. At Oak Ridge a homogeneous reactor will try on pilot plant scale the possibility of handling nuclear fuel in solution, moderated by heavy water. Data on these new developments are given in the words of the Atomic Energy Commission.

Experimental Breeder

As the year ended, construction of the building and facilities for the Experimental Breeder Reactor was going ahead at the Reactor Testing Station in Idaho. The small turbogenerator that will be run by the reactor in heat-transfer tests and power studies was

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being installed. The reactor itself was being fabricated at Argonne National Laboratory which designed it. This small reactor will explore the feasibility of creating more fissionable material than is consumed. It will operate in the high-energy neutron range.

A technical staff of about 30 people from Argonne will handle start-up, testing, and operating. Engineering design was by the Austin Co., of Cleveland; major construction by Bechtel Corp., of San Francisco.

Materials Testing

During the calendar year, basic design and development work progressed at the Oak Ridge and Argonne National Laboratories on the Materials Testing Reactor. Blaw-Knox Construction Co., of Pittsburgh, is doing engineering design and Fluor Corp., of Los Angeles, the construction at the Reactor Testing Station.

Phillips Petroleum Co., of Bartlesville, Okla., was selected as MTR's operator on a cost contract which provides for considering a fixed-price contract after experience with operation.

Operating in the thermal, or slow, neutron energy range, this reactor will supply scientists with a much needed tool to test materials under intense neutron bombardment.

Submarine Reactor

Construction of facilities for a land-based prototype Submarine Thermal Reactor was started at the Testing Station by two contractors to the Westinghouse Electric Corp., selected after competitive bidding: F. H. McGraw Co., of Hartford, Conn., and M. J. Brock & Sons, of Los Angeles. Engineering design of the facilities was done by the Rust Engineering Co., of Pittsburgh. The Argonne National Laboratory and Westinghouse, which are handling the STR project jointly, advanced their work.

Although this reactor is for the Navy, it is giving impetus to the ultimate use of nuclear energy for industrial power production.

Intermediate Reactor

During the first part of the year, the Knolls Atomic Power Laboratory deferred research and development on an Intermediate Power-Breeder Reactor and directed it toward a Submarine Intermediate Reactor power plant for the Navy. This reactor will operate in a neutron energy range intermediate between thermal, or slow, neutrons and high-energy neutrons.

Fluidized Reactor

Oak Ridge National Laboratory began a pilot model of a fluidized reactor, designated as the Homogeneous Reactor Experiment (HRE). The long-range planning group at ORNL reported on its studies of different types of fluidized reactors, and is continuing its work.

All other reactors built, except the Los Alamos Water Boiler, are heterogeneous, that is, the fuel and moderator are separate, and in most reactors both are solids. In a fluidized reactor, fuel and moderator are mixed in a liquid.

Aircraft Propulsion

During November the AEC took over from the Air Force contract arrangements with the Fairchild Engine & Airplane Co., for a portion of the Nuclear Energy for Propulsion of Aircraft project (NEPA) at Oak Ridge, Tenn.

The Technical Advisory Board to the Oak Ridge National Laboratory, composed of nuclear and aeronautic scientists, estimated progress in nuclear and aeronautic developments and suggested lines of work.

Sanitary Engineering

Development of an improved high-efficiency air filter was completed for AEC by Arthur D. Little, Inc., of Cambridge, Mass., and the filter was offered for manufacture by industrial concerns for commercial use.

The Weather Bureau and the Geological Survey supplied information essential for designing the chemical procesing plant at the Reactor Testing Station. The Geological Survey reported on the Valle Grande area in New Mexico, a potential source of water for Los Alamos. Arrangements were completed for a comprehensive survey of Columbia River in cooperation with the Public Health Service to study the effect of dams near the Hanford plants.

Harvard University undertook, under AEC contract, investigation of the distribution of radioactive materials introduced into water supply reservoirs and a conduit. The Massachusetts Institute of Technology was testing the effectiveness of conventional water supply treatment for radioactive decontamination. A research and development program was set up at the Oak Ridge National Laboratory with the Department of Defense and the Public Health Service on decontaminating water supplies, a first step being to test the effectiveness of a Corps of Engineers diatomaceous earth filtration unit in removing radioactivity.

Harvard University also undertook AEC research and development work on air cleaning partly in cooperation with Los Alamos Scientific Laboratory. The University of Illinois continued basic research on fine particles in air (aerosols).

Brookhaven National Laboratory began in 1950 research on the fixation of radioactivity on natural soils to gather new knowledge for developing improved methods of ultimate disposal of radioactive wastes. Johns Hopkins University completed work on the take-up of certain radioactive isotopes by slimes found in plumbing systems, while New York University completed studies of the effect of radioactive phosphorus on biochemical oxidation characteristics of domestic sewage.

Reactor Engineering

During the spring, a school of Reactor Technology was established at Oak Ridge National Laboratory to provide training needed by engineers for work in the AEC's reactor development program.

An interim course, starting in March, enrolled 18 men from AEC contractors and the military services for full-time studies over a period of a year. In September, the school started the first regular class with 43 students —23 men from contractors and the military services, and 20 recent college graduates temporarily employed by Oak Ridge National Laboratory who had been selected from 250 applicants from colleges and universities throughout the country.

Dual-Purpose Reactors

During 1950 the Commission received several inquiries looking to-

ward the designing and constructing of nuclear reactors with private capital and their operation and use by industry. While these inquiries were in general very preliminary proposals, they are a significant development in the field of industrial interest in atomic energy.

These expressions on the part of industrial investors represent a step toward realization of the objectives of the Atomic Energy Act of 1946. Industrial interest in nuclear reactors has been stimulated by AEC's technical information program, its training activities in the nuclear field and the experience of industrial firms in doing developmental work under AEC contract. At the same time, it appears from discussions with the industrial representatives and from the proposals themselves, that they stem from the desire of the companies to stay abreast of technological developments and to enter more fully in atomic energy industrial operations.

The Commission welcomed the proposals and is studying the problems involved. It is highly desirable to have industry enter the field of nuclear reactor development, design, construction, and operation on a basis in which incentives for aggresive and rapid technical and business development are present. The problems include the limited man-power, materials, and laboratory facilities and the relative urgency of defense projects.

On the Back Cover

➤ SECRET DOOR *to the hot cell is shown partly open to reveal the connections between outer control panels and shielded apparatus.*

Research apparatus previously tested by "dry runs" is moved into a hot cell for an experiment at the Hot Lab, Brookhaven National Laboratory, Upton, New York. Control apparatus on the front of the panel will remain outside heavy steel doors of the cell, while apparatus behind is sealed off inside the cell to protect personnel from highly radioactive chemicals. Each cell (rear) has concrete walls three feet thick and two steel doors, each one foot thick and weighing 11 tons.

By mounting the apparatus on a mobile panel, all equipment can be pre-assembled and pre-tested as a complete unit in another room before placement in the cell. Similarly, it can be removed as a unit to a special room for decontamination after use. Thus no time is lost between experiments in the cell itself.

With bamboo now being grown in the southern states and in Middle America, bamboo sprouts will be available but will probably not become as important an item in the American diet as they are in Japan and China.

Esparto grass, Stipa tenacissima, which covers millions of acres of rugged, almost sterile, land in Tunisia, Algiers and Morocco, is used to make hats, shoes, carpets and brooms, and as cattle feed, fuel and a base for paper.

Shapes and Sizes of Large Molecules Made Visible by Electron Microscope

Texture of Living Molecules

by RALPH W. G. WYCKOFF

Laboratory of Physical Biology, National Institute of Arthritis and Metabolic Diseases, National Institutes of Health.

An abstract of the Sigma Xi lecture given December 27, 1950 at the Cleveland Meeting of the American Association for the Advancement of Science.

➤ IT IS INEVITABLE that the instruments available at any time to supplement and extend our sensory perceptions of nature should determine in large measure the level at which our studies of the fine structure of matter can proceed. Thus the development of the compound optical microscope during the early part of the last century established the cell as the unit around which subsequent investigation of the structure of living matter has centered. It made readily visible the microorganisms that can function as single living entities as well as the individual cells which, functioning together, constitute the tissues from which the higher organisms of the plant and animal worlds are built. It has allowed us to observe such details within the individual call as its nucleus, mitochondria and chromosomes, and it has permitted the study of the interaction between the cells of a tissue during health and after the incidence of infectious or degenerative disease.

The research of the last century has made it amply clear that a cell lives by reason of the numerous chemical reactions that take place within it and between it and its environment. Biochemistry has isolated from living matter many of the substances that participate in these essential reactions and new physico-chemical methods, based on ultracentrifugation, diffusion and the like have been telling much about the molecules of these vitally important substances. These molecules are for the most part characterized by a large size that gives them weights ranging from a few tens of thousands to several millions. Over the last ten years the electron microscope has been mounting in importance because it extends our vision to include particles of precisely these weights. It has furnished a totally unexpected opportunity to see some of the molecular constituents of living cells and it is thus establishing a new branch of cytology which concerns itself with the macromolecular texture of the cell and the way this texture is altered by its vital processes, and by the disease that frequently overtakes it.

It is not easy to convey a proper understanding of the great extension in vision which electron microscopes give. Actually they have already made visible for the first time a world that is about as broad as that which was opened up by the optical microscope itself. The best electron micro-

scopes now available can reveal particles that are somewhere between 10 and 20A (*ca* 5 to 10 atoms) in diameter. Such a particle, having the size of a molecule of one of the smaller proteins, is a couple of hundred times smaller in linear dimensions than the smallest particles that can be delineated by optical microscopy; and such a particle (*ca* 0.2 micron in diameter) is smaller by about the same amount than the particles that call for the use of an ordinary hand magnifier. Thousands of scientific workers have been engaged for more than a century in perfecting the optical microscope and exploiting its potentialities. Electron microscopes have been available for only about ten years and one can scarcely expect either that they should be far advanced towards their ultimate design or that the few persons working with them should have made more than the most fragmentary explorations into the new fields of nature they have opened up.

Macromolecules

It will indeed take a long time to realize the ramifications of this new ability to see individual macromolecules. Direct measurements of molecular sizes and shapes are essential preliminaries to many profounder aspects of this new science. There is no immediate prospect of our being able to watch a significant biochemical reaction proceed under the electron microscope, but it is entirely feasible to observe beforehand the macromolecules of a compound that is to participate in a chemical reaction, and to see after the reaction whether important changes have occurred in macromolecular dimensions. Such a visual chemistry is for the most part a thing of the future but some progress has already been made, for example, in seeing how the elementary filaments of cellulose are broken down into small units during the dissolution involved in the manufacture of rayon, as well as in observing the new filaments of regenerated cellulose that are formed when rayon is spun. There are many reactions of protein chemistry, including the phenomena of denaturation, which could be illuminated by similar studies and it would be possible to investigate some of the phenomena of enzyme chemistry in this fashion.

Most of the solids important to biology are composed of macromolecules. The physical properties of these solids and their ability properly to fulfill their roles in nature depend on their molecular arrangement. Preliminary observations have shown the degree of order that prevails in some of these solids. It ranges all the way from perfect three-dimensional and truly crystalline order to the complete disorder that corresponds to the amorphous condition. The kind of visual crystallography that is developing from the examination of these macromolecular solids can do more than describe these various kinds of order in particle arrangement; by using these macromolecular solids as typical objects, it is attacking such basic crystallographic problems as how crystals form and what are the molecular disturbances responsible for the imperfections which all real crystals show.

Of the greatest importance are studies of how macromolecular particles are produced in nature and of

the way they are incorporated into the biological structures they form. This makes possible a new chapter in biology which deals with cytology and embryology on the molecular level. Viruses too are particles of macromolecular dimensions, and similar studies of their growth are throwing new light on their fundamental nature and on the molecular changes they bring about in the living cells that are their hosts.

There is an almost limitless possibility for further knowledge which is the inevitable consequence of this direct penetration to a deeper layer of nature. The electron microscope is no longer a tool which requires the special knowledge and ministrations of a professional physicist and its future will increasingly lie with experienced professional cytologists, histologists and pathologists rather than with physicists who are amateurs in the fields of science where its richest rewards now lie.

It is inevitable that in this broad study of the macromolecular composition of organic matter we should first concern ourselves with molecular size and shape. The earlier studies of such molecular morphology using the ultracentrifuge and associated methods were of necessity restricted to those substances which could be put into solution without too great change in their molecules. With the electron microscope we can not only seek to confirm these observations but we can also examine, for the first time, those insoluble macromolecular materials that are many of the frameworks of plant and animal tissues.

The particles of macromolecular dimensions thus far seen have, to a rather surprising degree, fallen into one or the other of two limiting groups; they have been approximately spherical, or they have been indefinitely long filaments. Most but not all the readily soluble macromolecular species have been compact sphere-like molecules. They include many of the virus proteins, the plant globulins, the respiratory proteins and the few enzyme molecules thus far recognized under the microscope. It seems likely that many molecular species responsible for the metabolic activity of living cells, and especially those that are transported within living tissue, will be of this sort.

Tobacco Mosaic Virus

The appearance of filamentous macromolecules under the electron microscope, and of any structures of which they are a chief component, depends strikingly on their thickness. The tobacco mosaic virus protein molecule, with a diameter of 150A is a stiff, straight rod, but thinner long molecules in solution have been as a rule curled and wavy objects. It is as if the more delicate filaments did not have the internal rigidity to withstand the buffeting effects of Brownian movement in a liquid in which they occur. This is equally true of filamentous molecules in true solution, such as those of the potato X virus protein or of fibrous actin, and of mechanically dispersed insoluble filaments, such as those of cellulose. The elementary bodies of viruses are macromolecular particles that range in size all the way from the lower limit of visibility under the optical microscope down to something smaller than the larger proteins from normal tissues. Most thus far recognized

have been roughly spherical but a few, like the tobacco mosaic virus, are rods and some show a diversity of form that can range from the spherical to the filamentous.

The shape of macromolecular particles is an important factor in determining the kind of solid they form. True single crystals, as well-defined as any found elsewhere in nature, can often be grown from spherical macromolecular substances. The molecular distribution has been seen over faces of crystals of several virus proteins, plant proteins and enzymes. From such observations one can of course directly deduce the molecular arrangement within the body of a crystal and this will aid materially in the X-ray diffraction studies now being made of the atomic arrangement and molecular structure of crystalline proteins. The electron microscopy of single crystals can reveal steps in their formation. It has already indicated how crystalline masses with terraced surfaces emerge from essentially formless molecular aggregates and how polyhedra with molecularly flat faces develop through the filling-in of these terraces.

Not True Crystals

The solids formed by filamentous macromolecules are more diverse and usually do not possess the three-dimensional regularity that characterizes a true crystal. Some, like the primary cellulosic walls of plants, are truly amorphous with molecules in disordered array. The same filaments of cellulose are arranged in parallel *sheets* in the secondary walls of plants. From plants such as ramie this parallelism is surprisingly perfect; from others it shows characteristic defects which undoubtedly influence the physical properties of commercial fibers. This tendency to yield sheets of parallel filamentous molecules is seen with many other substances; thus the fragments teased from striated muscle are such sheets. Where sheets occur naturally and are not produced by tearing apart more substantial structures, they are often only a few molecules thick. It is now feasible to cut sections thin enough for electron microscopy from plant structures, including wood. The examination of such sections has shown that secondary wall in wood as in simpler plants consists of stacks of thin layers each with its long axis turned with respect to its neighbors. A different degree of order prevails when filamentous molecules are stacked in ***bundles*** rather than in sheets. The paracrystals of the tobacco mosaic virus protein obtained by so-called "crystallization" from ammonium sulfate are such bundles, and so are the "crystals" of the muscle protein myosin. In rayon fibers the filamentous macromolecules of regenerated cellulose are in similar bundles with a degree of parallelism that is determined by the conditions under which the fiber has been drawn.

A study of vertebrate striated muscle in thin section has demonstrated that the component filaments of its anisotropic regions are in unusually perfect bundles. These regions contain more than the filaments, however, and examination of both longitudinal sections and teased ribbons shows that some of this other material is regularly distributed along the filaments. Thus it is apparent that three-dimensional order prevails within parts of muscle, but this order dif-

fers from that found in ordinary crystals by the fact that more than one molecular species contributes to it.

Many such multi-component structures occur in living systems. Especially important are the gels that have a liquid component. Most dilute gels we have examined in thin section show a solid component which is a spongy network of irregularly arranged interconnecting threads; in tobacco mosaic gels its molecules are, however, in well-ordered sheets and this indicates that disorder in arrangement of the solid component is not essential to gel formation. There is no way of knowing at the present time how faithfully the disordered anastomosing net obtained by sectioning dilute gelatin reproduces the particle arrangement in the native gel, but it is important that precisely the same type of sponge is seen in the axon of myelinated nerve fibers and as the groundwork of both the cytoplasm and the nucleus of cells.

How Cells Grow

This ability to see detail of macromolecular dimensions in sections cut through cells means that we can now inquire how this detail develops as cells grow and multiply, how cellular activity produces the various kinds of macromolecular solids that have just been illustrated and how the molecular fabric of the cell is altered by disease. Though studies of this sort have barely begun, some of their possibilities will be apparent from electron micrographs we have made of dividing cells, of the formation of connective tissue fibers and of virus development within infected cells.

The electron microscopy of dividing cells is beginning to reveal some of the macromolecular processes that underlie mitosis. There is no difficulty in sectioning plant tissues so as to reveal cells and their chromosomes; very serious studies are, however, needed to determine the best fixatives and dehydrating agents to use and to define the changes which even these may be expected to produce in native protoplasm. The chromosomes in early mitotic stages are fibrous in texture but those in metaphase and early anaphase have shown no fine structure which can be identified as persisting throughout the course of division, or with genes. Such studies are being amplified and it is obvious that they will in time be a most fruitful source of new information about cells and their proliferation.

As our background of knowledge about the macromolecular texture of cells develops, it will be possible to follow with increasing understanding the steps whereby the macromolecular structures of living matter are built up. Collagen fibers are especially attractive material for a preliminary study of this sort because some of the steps in their synthesis can be carried out in the test tube. As is now well-known, the collagen fibers in tendon and other tissues of the animal body are of indefinite length and of a variety of diameters. They are, however, typically cross-striated with a banding that repeats itself every 600-650A. Nearly twenty years ago Nageotte showed that extraction of fresh rat tail tendon with exceedingly dilute acetic acid gave a clear viscous solution from which sodium chloride precipitated a fibrous material that microscopically resembled fibers of the original tendon. At that time, Corey and

I found that such reconstituted collagen gave an X-ray diffraction pattern similar to that from tendon. Collagen reprecipitated from solution has lately been under examination with the electron microscope to see if it actually possesses the complicated fine structure seen in the native tendon. It does in fact have such structure, and much has already been learned about how this structure develops. Ultimately this should be helpful in understanding disease that involves connective tissue, but for the moment these observations are especially important in demonstrating that, given molecules of the proper complexity, periodic structures exhibiting elaborate fine detail arise when these molecules are brought together under suitable physico-chemical conditions of pH, ionic strength, etc.

Until recently it seemed probable that most knowledge of the way viruses grow and multiply would have to come from virus systems in which the cells were either isolated units, like bacteria, or were growing as sheets in tissue culture. The development of simple methods for cutting sections thin enough for electron microscopy has, however, changed this and made it possible to recognize and study many viruses within their hosts. Several viruses—of bacteria, plants, insects and the higher animals—have already been recognized within infected cells. As a result we have begun to see some of the steps involved in the formation of the elementary particles of these viruses and have commenced to recognize some of the characteristic molecular changes that occur in the cells they attack and destroy. It is very easy, for example, to recognize developing tobacco mosaic virus within infected tobacco leaves; a pox virus or influenza growing in chick embryo membranes is equally apparent. Beyond reasonable doubt the background of experience now being gained concerning the molecular fine texture of healthy cells will permit a similar identification of smaller viruses. Though much careful examination will be needed it seems clear that existing techniques are sufficient to give detailed information about the mechanisms of virus growth. Some viruses may multiply through a growth and splitting that resembles that shown by bacteria, but it seems evident that the multiplication of others is a more complicated affair.

Earliest Steps

It has not yet been possible to recognize the earliest steps in the infection of a cell with such a virus as fowl pox or vaccinia because the healthy epithelial cells that are their hosts ordinarily contain a few particles of virus size. The abnormal number of particles found after incubation for a day or two, however, permits their identification as virus. At a relatively early stage of infection many of the particles are larger and less dense than the final elementary bodies, and they appear deeply embedded in the little-altered cytoplasm of the infected cells. At a later stage they stand out more distinctly from an attenuated cytoplasm, while ultimately the virus bodies are seen aggregated within cells whose pronounced vacuolation indicates that little of the original protoplasmic net remains. It is probably unwise to

maintain at this time too definite ideas as to how the individual bodies have arisen, but there seems little reason to doubt that the infectious units present in ultracentrifugally purified suspensions are the end stage of a process of growth whose early phases are represented by the larger objects also seen.

The observations thus far made on virus-diseased insects do more to indicate the complexities involved in the growth of these viruses than to outline the processes through which it occurs. As is well known there are many of these virus diseases, each seemingly specific for one species of insect but all giving rise to so-called polyhedral bodies. Such bodies have now been observed with the electron microscope by several investigators and Bergold was the first to show that particles which probably are virus can be extracted from them.

Professor Kenneth M. Smith of Cambridge University and I have together been studying the polyhedra characteristic of a number of diseases, both as they are seen in section through infected insects and after their isolation from the animal. Probable virus particles have been found in some but not most of the polyhedra with which we have dealt. Those obtained from certain kinds of caterpillar have had the appearance of short rods, from others they have been spherical. The virus rods are associated with thicker bodies from which they may have developed. Evidently here, as in the case of vaccinia, the recognized virus particles seem to be the end product of steps whose earlier phases we can see and are beginning to recognize.

The bacteriophages that are the viruses of bacteria have been favorite objects for electron microscopy. Many photographs have been made which show what bacteriophage particles look like and which reveal many aspects of their growth from infected bacteria. But we are only beginning to see how their multiplication comes about; and as with the two other viruses just discussed, we are still very far from being able to describe adequately and with certainty the steps in this multiplication. The objects we do see that may be bacteriophage particles in course of development are found in and around the remains of lysed bacteria. Under favorable circumstances of lysis, much of the protoplasm of a bacterium may become transformed into a mass of bacteriophage particles. Some of these are morphologically identical with the mature particles found in such great numbers of filtrates and in their purified suspensions prepared by ultracentrifugation. But in suitably made preparations of the even numbered coli bacteriophages there are many objects that deviate progressively from the "mature" particles. Some have full sized heads but short tails; others have heads which, though of the usual size, contain so little material that they are greatly flattened by drying. In bacterial residues these insubstantial heads often appear as "holes" with which short tails are associated. Objects the size of these "tails" also occur separately in and about a lysed residue and in characteristic associations that distribute them about a central body in the way the spokes surround the hub of a wheel. It may well be that these represent stages in

the development of bacteriophage particles; if that is true then it is clear that even among this group of viruses there is more than one mode of multiplication.

There are numerous other viruses which can now be studied as they develop within their host cells. When enough work has been done it is inevitable that we shall have gained an entirely new understanding of the nature of viruses and the way they bring about the destruction of the cells that are their prey.

Chemistry Called Antidote to Mass Thinking

➤ WIDER study of chemistry and the other physical sciences as an antidote to the modern trend toward mass thinking was urged by Prof. Edward S. Amis and Prof. Allan S. Humphrey of the University of Arkansas at the sixth southwest regional meeting of the American Chemical Society in San Antonio.

Emphasizing the value of chemistry as a social study, their report said that the methods of chemistry if applied to other fields could make a contribution to the progress of civilization.

"The scientific method is one of careful and unbiased evaluation of the facts of a situation before coming to a conclusion," the paper explained. "In a world where people are persuaded and even forced to mass acceptance, no greater influence toward liberation of the individual could be originated than teaching the individual to think and evaluate."

Application of the scientific method in world affairs would prevent the pouring of all men into a common mould, the report said.

Individuals will think and consider. Problems will be carefully thought out. In a world of considered opinions and of thought out conclusions, undesirable, biased mass reaction will be minimized.

Continued training in a field which correlates facts and data will cause one to strive to organize and systematize phenomena and events in other life situations. He will be on the alert for relationships. One trained in this manner, when confronted with an unknown situation, will perhaps bring logic and organization to bear upon its solution.

Chemistry qualifies as a social study because it develops in men the ability to work harmoniously together for the accomplishment of a common objective; it has, as a science and profession, selfless and humane objectives, and has contributed much to the well-being of humanity.

Chemistry qualifies as a disciplinary subject since it teaches one to organize and classify matter, to see relationships among phenomena, to interpret the unknown in terms of the known, and to develop analytical thought processes.

New glass lenses that enable pilots to detect targets obscured by haze are made of a glass composition which absorbs scattered blue light rays characteristic of haze; they are a warm rose smoke in tint.

Chemicals Stop Clotting
Prevent Frost-Bite Gangrene

Blood-Clot Preventive Announced

➤ IF THE HUNDREDS of soldiers and marines reported to have frozen feet during the recent advances in Korea followed the old treatment of rubbing snow or cold water on their feet, they may have increased their chances of getting gangrene.

But their chances of escaping this and consequent loss of toes, feet or legs should be good if they were gotten quickly enough to hospitals equipped to give them treatment with heparin.

This anti-blood-clotting chemical and rapid thawing of frozen parts are the two latest methods reported for treatment of frostbite.

The fast thawing method is contrary to medical views and practice as recent as World War II. Experiments showing that it gives best results in treatment of frostbite were reported only a year ago by Dr. Harris B. Shumacker of Indiana University Medical Center.

The ideal temperature for thawing, he and his associates found, is one slightly above body temperature. Too much heat is bad, they cautioned.

Their findings came from experiments in which the tails of mice were frozen. When the frozen tails were rapidly warmed, no gangrene set in, but it did when cold was applied.

The rapid thawing is effective in part at least, Dr. Shumacker explained, because it shortens the period during which tissues are frozen and temporarily bloodless.

The Association of Military Surgeons, meeting in New York, were reminded of other experiments showing the value of the anti-blood-clot chemical, heparin, for treatment of frostbite.

One frostbite victim had been saved by heparin given when he reached the hospital after he had been lying in the street at least 14 hours in below freezing temperature with only low shoes and thin socks on his feet.

His feet and legs were ice cold up to the knee and remained so for five hours. Heparin was injected into his veins for five days. He developed considerable blistering, but was saved from any permanent loss of tissue or parts.

This and other cases were reported by Dr. Kurt Lange of New York when announcing their results with heparin treatment of frostbite in 1945.

Referring to this work at the meeting, Dr. Irving S. Wright of New York predicted that an anti-clotting drug which could be taken by mouth and be effective within an hour might be developed.

Use of the anti-blood-clotting chemical prevents thrombosis or clot formation in blood vessels which ultimately leads to gangrene. The dangerous thrombosis does not occur early in frostbite, Dr. Lange and associates found, but anti-clot treatment must be started before this stage of thrombosis is reached.

Drugs now used to treat conditions in which blood clots threaten to or actually do obstruct blood vessels are heparin, dicumarol and Tromexan. Other new ones, now under study, are BL-5, phenylindanedione and Paritol.

Accidental injuries in combat training programs as well as war wounds and operations are likely to increase the occurrence of thrombophlebitis, the blood-clot-in-the-veins condition, Dr. Wright pointed out.

The soldier who is not treated with suitable anti-blood-clot drug when he develops this condition in the saphenous veins in the leg has a 30% to 50% chance of suffering a clot on the lungs, Dr. Wright reported. After this, he has a 20% chance of having a fatal clot.

With correct anti-clotting treatment, the risk of the first clot on the lungs is reduced to five per cent and the risk of death five-tenths per cent.

Among the most common operations required by war is the repair of connections between an artery and a vein brought on by a penetrating wound. The variety of these is infinite as to type and location and often taxes the ingenuity of the most skillful surgeon. To get best results in such cases, a team trained in the use of the anti-clotting drugs should follow the patient through his operation and after.

Men in military service are also liable to heart disease, Dr. Wright stated. Thousands developed rheumatic heart disease in World War II. Many of these have or will develop the serious condition called auricular fibrillation and some will develop clots.

The use of anti-clotting drugs, notably long-time treatment with dicumarol, will prevent, in almost every case of fibrillation, the formation of clots within the heart and their release as emboli that are carried on to obstruct blood vessels elsewhere in the body.

This, Dr. Wright declared, is the only form of treatment which will attack this problem with any degree of success. As proof he cited a series of more than 100 patients treated with dicumarol while up and about for from one to five years, a total of over 400 patient years. Notable success without a single death from hemorrhage has been obtained with this group. This type of treatment, however, must be carried out only when it is carefully controlled, he warned.

More than 800 soldiers under 40 years old died of the serious heart condition called coronary thrombosis with myocardial infarction during World War II, Dr. Wright reported. The total of all ages who developed this condition would run into many thousands.

The death rate from this condition can be reduced one-third by the use of anti-clotting drugs, a study of 1,034 patients made for the American Heart Association showed. The rate of thromboembolic complications from this condition can be reduced by three-quarters by the same treatment.

Hemorrhage Controlled

➤ A METHOD of cutting down on the danger of hemorrhage and improving results in some serious operations has been reported by physicians in the University of California School of Medicine.

They have devised a way of using

anti-clotting chemicals locally, in areas near the site of operation. At the present time these chemicals, heparin and dicumarol, are given in such a way that they influence the whole blood stream. While this is very effective in preventing the formation of clots which might plug up an artery and cause death, it also raises the problem of hemorrhage.

The physicians insert a polyethylene plastic tube into the artery near the site, and introduce heparin into the artery slowly and steadily during and after the operation. Smaller quantities of the drug are needed, the blood in the danger area is kept fluid, and the danger of massive hemorrhage is reduced.

The method was worked out first on animals, and is now being used successfully on human patients. It is especially useful in operations on the extremities to remove blood clots which may threaten loss of the limb.

The work has been reported in part in the journal *Surgery* by Drs. Edwin J. Wylie, Richard E. Gardner, Robert Johansen, and H. J. McCorkle, all of the California institution.

Acids Linked to Plant Disease

➤ A CLUE has been uncovered to one of the unknown factors which make some plants more resistant to deadly fungus diseases than others.

With his study of black-rot diseases of tobacco, Dr. Robert A. Steinberg of the Department of Agriculture's plant research station believes that a poisoning process may be one key to this major biological mystery.

Certain amino acids, the physiologist found, seem to pave the way for the destroying fungus. Amino acids are vital substances linked to proteins in all living organisms. They play an important part in human nutrition, with more than 20 of them now known to science.

When some of these acids exist in excess in plants, Dr. Steinberg learned, they have a weakening effect on disease-susceptible plants, more so than on resistant varieties. One acid in particular is deadly. It was found to be lethal to tobacco seedlings at strengths as low as five parts per million.

In testing various of the amino acids with no disease organisms present, Dr. Steinberg discovered that they hit hardest at young tobacco plants which were known to be susceptible to black rot. Hardier strains of tobacco were affected least by the acids.

If it can now be shown that the fungus which causes a disease produces an excess of toxic acids in the plant system, a long step will have been taken toward better understanding of these diseases.

Sometimes completely ruining a farmer's crops in a short time, the fungus diseases can be fought by chemicals. But the only permanent defense is the work of plant breeders who cross and recross strains to produce plants with built-in resistance against disease.

Some Elements Abundant: Others Easy to Discover

Metallurgy of Less Familiar Elements

by BRUCE W. GONSER

Battelle Memorial Institute, Columbus, Ohio.

➤ THE BORDERLINE between common metals and those which are rather vaguely termed the less familiar metals is constantly changing. An uncommon metal today may be commonplace tomorrow. A familiar example is the way aluminum and magnesium, which were on the dark side of the border not many years ago, have moved over to places of major commercial importance. Titanium and zirconium are preparing to step over soon. Many metals are looming in the background as contenders for the position of the currently most important new useful metal of the future.

Of the 98 elements reported so far, over two-thirds are metals. Of these, hardly more than a dozen are really common; hence there is a substantial reserve of metals on which to draw for those unique properties which scientific advances are always demanding. It is obviously impractical to cover the metallurgy of all of these in one short discussion. Instead, major attention will be given to the general methods being developed for obtaining the pure metals, to metal coatings over base metals, and to a few of the most interesting and potentially important of the unusual metals. Thus, emphasis is given to chemical metallurgy rather than the equally fascinating developments in physical metallurgy.

There are three main considerations in determining the probable usefulness of a metal: availability, ease of extraction, and properties. Modern civilization demands vast quantities of metallic products, and, unless the earth can supply the metal in substantial amount, its use is handicapped, regardless of the excellent properties it may possess. The platinum group of metals, for example, would be a wonderful addition to our list of structural materials if they could only be regarded in terms of available tons in place of ounces. The difficulty of metal recovery, which strongly influences cost and large-scale production, plays an important, though frequently a temporary, role. This is the challenge to the metallurgist. Sometimes the true properties are not uncovered because the metal has never been made in a sufficiently pure form. Extraction problems, then, may temporarily obscure an abundant and desirable metal, as it has done with titanium, while a metal with poorer over-all properties but which is easily reduced, as zinc, or tin, or mercury, has been used for many centuries. Properties, of course, form the greatest consideration. Thus, the valuable properties of uranium and radium overbalance their scarcity and difficulty in extraction, whereas sodium and silicon, which are in overwhelm-

TABLE 1.

RELATIVE ABUNDANCE OF METALS IN THE EARTH'S CRUST†

(Aluminum taken as 100)			
Silicon	313	Sodium	32
Aluminum	100	Potassium	29
Iron	58	Magnesium	24
Calcium	41	Titanium	7
(Range of 1.0 to 0.1%)			
Manganese	1.06	Zirconium	0.22
Strontium	0.48	Rare earths	0.14
Barium	0.44	Nickel	0.11
Rubidium	0.35	Copper	0.11
Chromium	0.23	Vanadium	0.11
(Range of 0.10 to 0.01%)			
Tungsten	0.08	Lead	0.02
Lithium	0.07	Molybdenum	0.02
Tin	0.05	Niobium (Cb)	0.02
Zinc	0.05	Tantalum	0.02*
Cobalt	0.05	Gallium	0.02
Yttrium	0.04	Thorium	0.01
(Range of 1 to 8 lbs. per 100,000 lbs. of Aluminum)			
Germanium	0.008	Uranium	0.005
Cesium	0.008	Hafnium	0.004
Beryllium	0.007	Boron	0.003
Arsenic	0.006	Antimony	0.001
Scandium	0.006		
(Range of 1 to 7 lbs. per 1,000,000 lbs. of Aluminum)			
Selenium	0.0007	Bismuth	0.0002
Cadmium	0.0006	Tellurium	0.0001*
Mercury	0.0006	Indium	0.0001
Thallium	0.0003	Silver	0.0001
(Really Rare Metals)			
Palladium	0.000011	Rhodium	0.000001
Gold	0.000006	Rhenium	0.000001
Platinum	0.000006	Osmium	1.0^{-7}
Iridium	0.000001	Radium	1.0^{-9}
Ruthenium, polonium, new elements—			

ing abundance and recoverable at low cost, find a greatly disproportionate field of usefulness.

Table 1 gives a tabulation of most of the metals in order of their abundance in the first 10 miles of the earth's crust. These are fairly well-known data which have been rearranged to show an abundance comparison, with aluminum as 100. Fortunately, minerals of even very scare metals are frequently concentrated and rather easily found; hence, there is not necessarily a direct quantitative relationship between the immediate availability of a metal and its position in this tabulation. This does give a fair idea, however, of the fundamental availability of the metals in the future.

† Goldschmidt, J. Chem. Soc., 1937, Pt. 1, pp. 655-673.

* Value not given by Goldschmidt, estimated from general position with associated elements in data by Clark and Washington (Professional Paper No. 127, USGS, 1924).

TABLE 2.

ABUNDANCE — EASE-OF-REDUCTION RELATIONSHIP TO COMMON USE.

Relatively Scarce, Easily Reduced	Abundant, Easily Reduced	Abundant, Difficultly Reduced
Copper	Iron	Aluminum
Lead		Magnesium
Tin (bronze)		Titanium
Zinc		
Mercury		

Examples of the influence of ease of reduction of metals from their ores on their adoption as common metals are given in Table 2. Some of our oldest metals, as copper, tin, gold, silver, and lead, were not necessarily in abundance, but ease of reduction gave them a preferred position among early useful metals. Iron, in great abundance, but still comparatively easy to reduce, soon assumed the emperor's position, which it still holds. More recently, the abundant, but difficultly extracted metals, as aluminum, magnesium, and titanium are moving into a role of increasing importance. This trend is continuing at a constantly accelerated pace as new materials, techniques, and needs catalyze the rate of research and development.

Types of Processes

The normal carbon reduction of metal oxides, so effectively used on a large scale in the blast-furnace smelting of iron, lead, and antimony, or in the reverberatory smelting of copper and tin, finds only limited application in reduction of the scarcer, more refractory, and less well-known metals. This also holds for carbon reduc-

tion accompanied by volatilization and condensation of the reduced metal, long used in zinc metallurgy. However, the heating of metal oxides with carbon, accompanied by chlorination, or to produce other halides, is a useful method for obtaining a volatile or soluble compound of many refractory metals, which then can be separated from other constituents and reduced. Thus, magnesium chloride has been prepared in this way on a large scale for subsequent recovery of the metal by electrolysis; zirconium chloride is so produced and zirconium is recovered subsequently by reduction with magnesium.

Electrolytic Processes

One of the most effective methods for producing pure metals, of course, is by electrolysis. This has been used both for primary recovery and for refining of most of the common metals. Deposition from aqueous solutions also has been used effectively to produce indium, gallium, thallium, and cadmium. An interesting variation when using an aqueous electrolyte to recover a reactive metal is to use a mercury cathode and later recover the deposited metal by distillation of the mercury. This was demonstrated by Mme. Curie and coworker some 40 years ago in producing metallic radium, and the same principle finds occasional applications now, as in exploring means for producing a metal powder.

Incidentally, using mercury as a convenient tool to gather those metals with which it amalgamates, and later removing the mercury by distillation, has a far greater field than in electrolysis. This field has been aptly referred to recently as "Amalgam Metallurgy."

Some reactive metals have been successfully deposited from solution in non-aqueous electrolytes. Although not yet important commercially, the exploration of non-aqueous electrolytes in research has been producing interesting results, and this is definitely a field of metal recovery and plating that should not be overlooked. As examples, lithium can be deposited by electrolysis of lithium chloride in pyridine; heavy deposits of aluminum can be deposited from aluminum chloride and ethylbromide (or ethyl pyridinium bromide) in toluene. Liquid ammonia has been used as an electrolyte to deposit experimentally beryllium, thallium, arsenic, and some of the precious and common metals.

The most successful electrolytic method for recovery of reactive and refractory metals has been the use of a molten-salt electrolyte. This forms the basis for the very successful commercial production of aluminum, magnesium, sodium, and the other alkali and alkaline-earth metals (Li, K, Rb, Cs, Ca, Sr, and Ba). It is also a means for producing uranium, beryllium, thorium, cerium, and metals of the rare-earth group, including the impure mixture known commercially as misch metal. This procedure is particularly convenient when the electrolyte is at such a temperature that the metal is deposited in the molten state so that it can be removed continuously.

Some of the high-melting metals can be reduced electrolytically from their molten salts, but instead of forming a molten pool or a coherent deposit they become distributed through the electrolyte as a crystalline metal powder. This is the case with tan-

talum and niobium (columbium). The electrolyte here is a double fluoride with potassium. Massive metal is obtained by dissolving the soluble salt away from the product, recovering and washing the powder in a tabling operation, and pressing and sintering the tantalum or columbium by powder metallurgy. There is reason to believe that some of the other high-melting metals, as titanium and zirconium, can be reduced electrolytically in a molten-salt electrolyte also, but with a more difficult problem of recovering a nonmassive deposit in a sufficiently pure form to obtain a ductile metal.

Metal Replacement

Trading one metal that is expendable to throw another metal out of solution is another well-known electrochemical procedure that is finding many new applications and a few variations. One of the oldest applications, cementation of copper on iron, as by adding shredded tin cans or other scrap to copper-containing mine waters, is a common sight to observant travelers in the copper-mining districts of the West. Zinc dust has been a particularly useful replacement metal, not only in the well-known precipitation of gold and silver from cyanide solutions, but in the removal of many metals from solution, as in purification of a zinc sulfate electrolyte prior to electro-deposition. Since indium, germanium, gallium, and cadmium are frequently associated with zinc ores, this replacement reaction may give these metals in sufficient concentration to warrant subsequent separation and recovery. This is true not only in recovery of by-products from an electrolytic zinc plant, but in the hydrometallurgical treatment of the baghouse and Cottrell dusts from a pyrometallurgical zinc plant.

More recently, metal replacement has been used in dry, high-temperature reactions. Many of these processes are variations of the thermite type of reaction, using aluminum, magnesium, silicon, or other alkali or alkaline-earth metal to break up a metal compound. Thus, work is in progress to obtain titanium by reacting purified calcium with titanium dioxide; thoria is reduced to thorium by calcium reduction in presence of calcium chloride; uranium can be reduced from its oxides by calcium, magnesium, or aluminothermically. Ductile vanadium has been prepared by calcium reduction of vanadium pentoxide. Barium and strontium can be produced by oxide reduction with silicon or aluminum in a vacuum at 1150°C. Silicon has been used recently with technical success in large-scale reduction of magnesium oxide to magnesium which was volatilized and condensed to give the commercially pure metal. Such reactions take place in vacuum, or at least in an inert atmosphere. Replacement reactions involving reduction of metal halides are discussed later.

Another variation of metal replacement is to carry out the reaction in a molten-salt medium. Little work has been done in this field and it forms a promising area for development. Metal coatings have been produced conveniently by replacement in a fused-salt bath. Tin alloys may be formed on copper, iron, and some other metals by immersion in a molten chloride-salt mixture containing stannous chloride; excellent chromium-iron diffu-

sion coatings are formed on iron and steel articles by immersion in hot molten barium chloride containing chromous chloride as a constituent. This has the advantage, under some conditions, of greater speed and ease of control than when using solid materials or a volatilized constituent.

Halide Metallurgy

In producing many of the uncommon metals, it is easier to reduce their halides than their oxides. There are so many applications and ramifications to this general method of treatment that it justifiably can be called halide metallurgy to differentiate from the older fields of normal pyrometallurgy and hydrometallurgy.

Dry replacement reactions, or reduction of a metal compound by a more active metal, in many instances works particularly well when the metal compound is a halide. The magnesium reduction of titanium chloride, or of zirconium chloride, is a good example. By passing either of these chlorides into a bath of molten magnesium, rapid reduction takes place exothermically, and, on completion, the resultant magnesium chloride and residual magnesium may be volatilized away to leave a metal sponge suitable for arc melting to massive metal. Similarly, silicon of high purity has been prepared by reacting purified silicon tetrachloride with zinc vapor. Calcium reduction of uranium fluoride is a preferred method of obtaining pure uranium.

Hydrogen reduction of metal halides is assuming increased importance, particularly as materials of construction to resist the resultant hydrogen halide are improved. Cobalt, nickel, and iron powder can be produced by reduction of the solid chloride at a rather low temperature. Reduction of volatilized halides by hydrogen has been of particular interest in producing metal coatings. Thus, many of the high-melting metals, as tungsten, molybdenum, tantalum, and columbium, that are difficult to get in massive form are readily deposited by volatilizing one of their halides and reducing it on a heated metal surface with hydrogen. Production in Germany of titanium by hydrogen reduction of titanium tetrabromide has been described—as well as reduction of the tetrachloride with sodium and the oxide with calcium hydride.

Fortunately, many of the halides decompose by pyrolysis alone. Titanium, zirconium, hafnium, thorium, vanadium, and chromium are among the metals which can be produced in a very pure massive form by thermal decomposition of their iodides. This can be done by passing the pure iodide into a previously evacuated chamber containing a heated surface, as an electrically heated wire, or by using a bulb in which a crude metal charge is present and iodine serves as a carrier between the charge and the heated surface. This reaction is not limited to the iodide by any means, but, in many instances, the iodide decomposes at a lower temperature, and iodine can be more conveniently handled and recovered (as the liquid or solid) than the other halides. Molybdenum and tungsten are more readily obtained from their respective chlorides or bromides.

Another associated type of reaction which offers interesting possibilities is the formation of a volatile subhalide

at an elevated temperature which disproportionates at a lower temperature. Thus, aluminum trichloride (or bromide or fluoride), when heated in the presence of metallic aluminum, and preferably under partial vacuum, forms a subchloride. This volatile compound disproportionates on cooling into aluminum and the trichloride. The reaction consequently has possibilities in refining or recovering high-purity aluminum from a low-grade crude metal. Similarly, as familiarity grows with the high-temperature properties of compounds of the less familiar metals, other examples may be found where this becomes a useful metallurgical procedure.

Metal Coatings

Closely associated with the recovery of pure metals from their ores is the deposition of metals as coatings on another metal base. This is particularly important with the unusual metals, to secure a desired surface at less cost, or for protection against oxidation or corrosion. Some of the techniques and reactions common to both coating and metal-recovery work can be best described under coatings. However, coatings applied electrolytically are considered to be outside the scope of this discussion.

Volatilized Halides

Coating by pyrolysis of a volatilized metal compound (usually a halide) is not common, but it has been well demonstrated in the laboratory. Uranium, thorium, vanadium, titanium, zirconium, and hafnium may be deposited by thermal dissociation of their respective iodides either in an inert atmosphere or at low pressure. The temperature required for decomposition is usually in the range of 800-1800° C., and the choice of base metal to secure a pure metal coating is limited, but coatings sometimes can be applied by this method when other methods fail. Rhenium can be plated similarly by decomposition of the volatilized chloride.

Hydrogen reduction is more readily applied to the decomposition of many volatilized metal halides. A somewhat lower temperature and atmospheric pressure can be maintained. This is the preferred way to coat various metals with tantalum, niobium (columbium), molybdenum, tungsten, boron, and silicon. With reactive base metals, diffusion of the coating takes place into the metal base, and replacement may occur, as well as some reduction by the hydrogen atmosphere. In siliconizing steel by passing silicon tetrachloride over a heated steel object, for example, a coating can be formed entirely by replacement of iron, or, with a high concentration of hydrogen in the atmosphere, part of the silicon may be deposited by reduction and part by replacement.

Because of the need for materials to resist very high temperatures, there has been a growing need for refractory coatings to protect high-melting metals which have the mechanical properties desired but not the oxidation or corrosion resistance. Vapor-deposition methods form a particularly useful field for securing stable and unusual coatings. Aside from applying metals by this means, carbides, borides, silicides, nitrides, and even oxide coatings or mixtures have been so applied. By mixing volatilized metal compounds, two or more metals can be codeposit-

ed under proper conditions; many carbides can be deposited by using a hydrocarbon gas along with the hydrogen atmosphere. Thus, this general means of coating is a powerful, versatile tool which is expected to have many practical applications in the future. The various reactions and a survey of the methods used to form refractory coatings by vapor deposition have been covered in recent publications.

As an example of refractory-coating development, by siliconizing molybdenum (passing silicon tetrachloride gas in hydrogen over molybdenum) a remarkably oxidation-resistant coating can be formed which will withstand temperatures up to 1700°C. for many hundreds of hours. Even higher temperatures and longer times for useful operation appear to be possible. A corollary to such work is the casting of the molten coating material to give a solid body, or forming such a refractory molybdenum-silicon base body by powder metallurgy.

The use of a molten salt bath as a medium to effect metal coating by replacement has been mentioned previously. In chromizing steel by either gaseous or molten-salt replacement, it is possible to secure impervious, corrosion-resistant coatings, or, by dissolving out the steel core, to make tubes and other hollow metal objects.

Thermal decomposition of a metal carbonyl gas has been used for many years in refining nickel, and more recently in making a high-grade iron powder. Considerable laboratory work has been done on depositing some of the less common metals from their volatilized carbonyls — particularly tungsten and molybdenum. The platinum-group metals may be deposited by thermal decomposition of their carbonyl halides, and platinum has been deposited from certain other organometallic compounds, such as the acetyl acetonate. However, such deposition is still at the laboratory curiosity stage. In considering ways to recover a pure metal, as well as to coat with it, carbonyl formation is a factor worth noting.

Vacuum evaporation and cathode sputtering are coating methods applicable so far only in making very thin coatings. It is possible with some of the more volatile metals to literally vapor coat, as with antimony, arsenic, and zinc, by reaction of the metal vapor with a base metal. The low-melting metals frequently can be used in hot-dipping baths.

Metal spraying has advanced to the point where a surprisingly large number of metals can be sprayed onto a nonmetallic as well as metallic surface. This includes high-melting metals such as molybdenum, tantalum, and even tungsten. An interesting innovation has been the use of a plastic into which a metal powder can be incorporated and the mixture extruded to form a wire for use in a metal-spraying gun. This is useful in applying a nonductile metal.

Hydrogen Reduction

Although hydrogen reduction of metal compounds has been partially covered in discussing methods of metal recovery, the growing importance of hydrogen as a reducing agent in commercial metallurgy deserves special mention. Not long ago, the explosion hazards in handling hydrogen were considered to be such that serious consideration would scarcely

be given a method that involved its use. It is still regarded with suspicion by metallurgical plant managers. However, advantages in its use for many applications are such that a metallurgical process involving hydrogen is given attention, at least. In the metallurgy of many of the unusual metals, hydrogen is practically indispensable.

Tungsten is produced by hydrogen reduction of tungstic oxide; molybdenum is likewise produced from molybdic oxide. Rhenium is most conveniently prepared as the metal powder by reduction of potassium perrhenate at about 1000°C. in hydrogen. There are many other examples.

A convenient way to effect reduction of some unusual metal compounds is to use the hydride of a reactive metal, whereby a combination of replacement, active-hydrogen reduction, and a protective hydrogen atmosphere may be attained. The production of calcium, sodium, lithium, and other metal hydrides has become a thriving commercial enterprise. Calcium hydride, used during World War II as a convenient source of hydrogen for balloons, is perhaps the most important for reducing various refractory oxides, including titanium and zirconium oxides. This usually first gives a hydride of the metal being reduced but it is readily converted to the metal by heating. Some of these hydrides form a useful pure-hydrogen "sponge" by absorbing hydrogen at one temperature and releasing it on heating more strongly.

Many of the hydrides of the unusual metals (as of germanium, indium, gallium, thallium, arsenic, selenium, and tellurium) are volatile. These can be reduced thermally. This procedure sometimes forms a very convenient way of selective plating or of deposition on glass or other nonmetallic objects.

The commercial use of vacuum technology has increased along with the increased use of hydrogen and of inert atmospheres to handle the most reactive of the unusual metals. Some metals, like titanium and zirconium, react with practically everything but the inert gases, and vacuum or an atmosphere of helium or argon is needed in preparing equipment for the reduction operations and in melting or oxide-free annealing. Here again, so many metallurgical applications have been found that the term "vacuum metallurgy" has been effectively used.

Radiation Helps Heart Cases

➤ PATIENTS with severe and intractable heart disease may benefit from large doses of radioactive iodine, it appears from good results reported to the Radiological Society of North America by Drs. Richard H. Chamberlain, Charles C. Wolferth, Jack Edeiken and John J. Meade of the University of Pennsylvania.

Best results were obtained by those with severe angina pectoris. Most of these showed marked improvement. Those with severe congestive heart failure did not get as much benefit, although 27% experienced good relief and another 27% fair relief. How long the good effect will last is not yet known.

Convenient Refrigerant Has Other Novel Uses

Dry Ice

by GEORGE B. ARMSTRONG

Manager, Carbon Dioxide Division, Mathieson Chemical Corporation

➤ THE "BUBBLE" in your soft drink is one of the most versatile and least publicized genii in the magic world of chemistry.

Carbon Dioxide (CO_2), known since the time of the Roman Emperor Tiberius, yet still in its infancy as a servant to man, is a waste product from animal life but food for the vegetable kingdom. It can exist as a gas, liquid or solid.

It can take a life or save one. It is used in science, medicine, industry and the entertainment field. It is used by people in every walk of life: from the Good Humor man to the scientist working in his laboratory, from an airplane pilot to a surgeon in an operating room.

History

About the year 1600, van Helmont learned that CO_2 was a gas. He discovered that the burning of charcoal produced, besides an ash, a gas he called "spiritus sylvestre." This gas was identical with the gas given off during the process of fermentation.

Others, including the famous Joseph Priestley and Lavoisier, added immeasurably to the understanding of the gas. The latter gave to the unnamed gas the name "acide carbonique" which has the English equivalent "carbonic acid." This term is now generally used for the water solution of the gas carbon dioxide.

Michael Faraday's and M. Thilorier's experiments on the liquefaction of the gas influenced the future of the entire industry. By 1835, Thilorier produced carbon dioxide "snow" for first time. This "snow", compressed, is dry ice. Most of this early work was on liquid CO_2 and in developing compressors for the liquefaction of the pure gas.

Solidified carbon dioxide was first manufactured commercially during the early 1890's when machines to compress snow were patented. But until the 1930's it remained a high cost, luxury item used chiefly for laboratory work. Today, the production of the solid form of carbon dioxide, dry ice, just about triples that of liquid CO_2 because of its many advantages as a dry, compact, extremely cold refrigerant and its economy, versatility and cleanliness.

Properties

Chemically, carbon dioxide is not an active compound and reactions between dry CO_2 and other compounds and elements, can, in general, be promoted only at high temperatures. It is a colorless, odorless gas always present in the air, although the concentration is only .04%. It is composed of approximately 27% carbon and 73% oxygen. It is soluble in water and will not support combustion.

It is continually given off to the

➤ SALTVILLE, *Va. is the home of the dry ice manufactured by the Mathieson Chemical Corporation, largest single dry ice works in the world.*

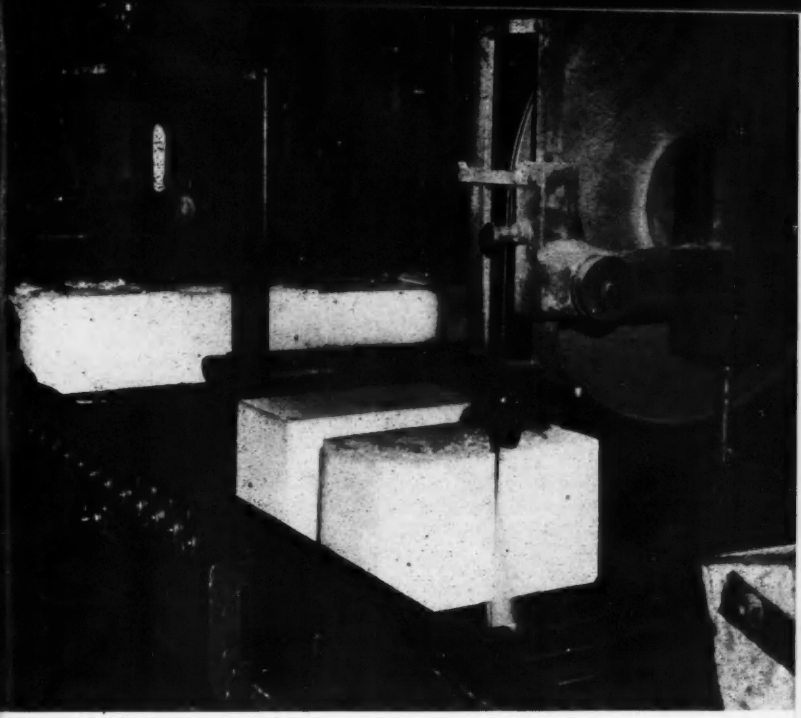
air in the exhalations of all living animals, the burning and decaying of organic matter and by volcanoes and other fissures in the earth. It is taken up from the air and kept in a state of balance by growing vegetation which makes use of carbon dioxide in photosynthesis, retaining the carbon as feed material and giving off oxygen in return.

Carbon dioxide gas will not support combustion or life. A concentration of 25% in air will, if breathed, cause asphyxiation. Actually carbon dioxide is non-toxic. Death is caused by lack of oxygen. CO_2, heavier than air (or oxygen), displaces it.

Like water, CO_2 may exist in any of three phases—solid, liquid and vapor. Just as the normal state of water is liquid, that of carbon dioxide is vapor. It may exist as a solid at atmospheric pressures but cannot exist as a liquid unless confined under pressure.

Dry ice is a white, semi-translucent solid, manufactured by compressing CO_2 "snow" into a solid mass. When it sublimes (passing from a solid into a vapor without the formation of a liquid) at atmospheric pressures, it

➤ WORK *with high pressures is characteristic of the manufacture of carbon dioxide in its liquid and solid forms. The energy absorbed when part of the liquid flashes into gas is used to drop the temperature to the point where* CO_2 *snow falls in the pressure apparatus.*



➤ Blocks *of solidified CO_2 snow are cut to convenient size. Carbon dioxide is heavier than water, but forms gas instead of liquid as it melts.*

produces a temperature of —110°F. It has twice the refrigerating value of water ice by weight and about 3½ times the value by volume. No liquid is formed.

Commercial dry ice, over 99.5% pure CO_2, is an excellent means of shipping the gas. Soft drink bottlers make extensive use of this by having in their plants dry ice liquefiers, or convertors. Dry ice is introduced into these high-pressure vessels, the pressure built up and all of the ice converted into liquid carbon dioxide with an overlying head of vapor. The bottler withdraws the vapor from the top of the convertor and runs it through copper lines to his carbonator.

Manufacture

CO_2 gas is obtained from seven basic sources but many different methods are used to bring the raw gas to the same standard of purity. The seven basic sources are gas wells, springs, fermentation vats, flue gas, oil refineries and the chemical industry. The chemical industry is the largest of these suppliers.

The largest single dry ice works in the world is Mathieson Chemical Corporation's plant at Saltville, Virginia. Mathieson obtains raw carbon dioxide gases by "burning" limestone in kilns. The gases from the lime kiln stacks, with CO_2 comprising a large portion of the total, are passed through a water scrubber and a soda scrubber which remove the dust and cool the gas.

The cleaned and cooled gases are then blown upward through several towers against the downward flow of a special organic base absorbent called monoethanolamine or MEA. This MEA takes only the carbon dioxide from the total gases which are passed out into the air from the top of the absorbing towers.

The MEA absorbing solution, carrying the CO_2 within as a loose chemical compound, is pumped into a boiler where steam heats the solution and the high temperature drives off most of the carbon dioxide while the now dilute MEA passes back to the towers to pick up more CO_2.

The stream of CO_2 gas driven from the boiler is water cooled and then scrubbed chemically to remove foreign matter. Over 99% pure at this stage, it is cooled and passed into a gas holder.

When needed, it is taken from the holder and passed through a three-stage compressor, leaving it at about 1100 lbs. pressure. The pure high-pressure gas is scrubbed again, to remove any water vapor or oil picked up during compression, and cooled to below the critical temperature of 88° F, where it liquefies and passes to storage.

Cylinders can be filled or tank cars or trucks loaded with the cool liquified carbon dioxide but to produce dry ice economically the cool liquid must be further sub-cooled. This is accomplished by allowing it to flow into expansion tanks where approximately half of the liquid "flashes" into gas.

The liberated gas is passed back into the compressor system, while the very cold liquid—about minus 30°F —flows into the dry ice press chamber. When suffcient liquid is contained within the chamber walls the flow is shut off. The pressure is then suddenly released, flashing the liquid in the chamber; this converts slightly over half of the CO_2 into a light fluffy snow. The remainder of the gas is returned to the compressor system.

The snow is compressed under a hydraulic pressure of 2200 pounds to form a solid block of dry ice measuring approximately 20" x 20" x 10", and weighing about 220 pounds.

The large block is taken from the press on to a conveyor where it is cut twice to yield four 10" cubes, weighing approximately 55 pounds. Each block is carefully wrapped in heavy Kraft paper bags and immediately loaded into specially insulated freight cars or storage containers.

Because of its perishable nature the distribution of the solid product must be carefully scheduled and planned. Manufacturers such as Mathieson, must accept a certain loss in the interval between manufacture and sale. To keep this evaporation loss at a minimum, heavily insulated rail cars have been built. The cars have as much as 20 inches of side wall in-

▶ DRY ICE *refrigeration containers fit onto standard freight cars but protect their contents to the end of the journey without re-handling.*

sulation with corresponding thicknesses in the roof, floor and ends.

The ice, which remains in the car until sold, is at minus 110°F, low enough to "burn" the skin on relatively short contact.

Uses

The uses of carbon dioxide in its different forms extend into almost every field of endeavor. Every day someone thinks of a new use for this amazing product. The most important application and the one that consumes the greatest tonnage is the very wide field of refrigeration. This, naturally, requires the solid form—dry ice.

Dry ice, because of its highly compact nature, is in demand where refrigeration weight and space are design factors. No provision need be made for the disposal of water from melted ice, an important factor in truck refrigeration. Such liquids corrode wood and metal body members which must be replaced. Indeed, the gas given off by dry ice acts to "inert" the interior atmosphere of refrigerated units. The absence of air and moisture greatly increases their life.

The ice cream industry is perhaps the largest user of dry ice and the growth of the two industries is closely allied. The neighborhood ice cream wagon, such as the well known Good

Humor man, probably owes its successful existence to dry ice. Other vital refrigeration uses include: low temperature drying of biologicals such as Penicillin; freezing of water pipes to stop the flow so that repairs can be made close to the break; cold temperature treatment of special steels to increase their hardness; and cold shrinking of machine parts so that tolerances hitherto undreamed of can be met and maintained.

Also in the general field of refrigeration is the hardening of newly made moulded rubber objects. They can then be trimmed by tumbling one against the other so that very thin edge "flashes," made brittle by the low temperature, are broken off. Perishables such as meat, frozen foods, fruits and vegetables, flowers, milk, etc. are transported under dry ice refrigeration.

Adding greatly to its worth as a refrigerant is the inerting effect of the gas given off during sublimation. Driving out the air surrounding perishables eliminates surface molds and other oxidization products. Often, because of this inerting effect, higher than normal carrying temperatures can be maintained.

The carbon dioxide gas used by soft drink bottlers may be furnished to them in the form of dry ice or as a liquid in cylinders. The product is the same. Bottlers consume huge tonnages of all the carbon dioxide produced. It is highly dangerous to enclose dry ice in a sealed container where the gas will build up sufficient pressure to explode the container. The steel cylinders and liquefiers used in the industry are specially built for this purpose. For example, dry ice should never be placed in a glass jar with a closed lid.

Liquefied carbon dioxide when released from pressure expands to 450 times its stored volume. Small cylinders of the liquid attached to life vests and rubber life boats and rafts will inflate them in a few seconds. This tremendous pentup energy will also perform such emergency operations as opening bomb-bay doors and releasing landing gear when regular hydraulic equipment fails. This enormous expansion is used by other industries to perform many tasks, such as spray painting, operating bell buoys which mark ship channels and testing for leaks and purging water wells.

When the area surrounding the bore of a well becomes clogged with silt or other matter, dry ice may be introduced into the well and a fairly tight wooden plug placed in the mouth of the well. The pressure formed in the bore blows outward and "cleans" the underground strata feeding the well. This method often causes so-called "dry" wells to flow again.

In the chemical industry, carbon dioxide is extensively used, as in the manufacture of salicylic acid for aspirin, synthetic urea and wet process white lead. The very high initial purity of this raw material is most satisfactory to the chemical industry.

A better known and very important use of liquid carbon dioxide is in fire fighting. This requires that liquid, not vapor, be withdrawn from the CO_2 cylinder, which is accomplished by a dip-tube extending to within a fraction of an inch of the bottom of the cylinder.

Liquid CO_2 has a number of distinct advantages. Because of its great expansion CO_2 "blankets" all crevices with an oxygen-free atmosphere. The formation of dry ice snow, as the liquid leaves the nozzle of the extinguisher and falls on the fire, acts to cool the burning matter quickly to below the ignition point. No damage is done to surrounding stock since the dry extinguishing agent evaporates. The net effect on a fire is to cool the burning matter and to surround it with a blanket of non-combustible gas. The fire smothers.

Engine fires on airplanes are quickly smothered by flooding them with carbon dioxide. Carbon dioxide "crash trucks" at airports and flying fields have saved many lives.

Miscellaneous uses for dry ice seem to be legion and new applications are announced daily. A new type of gun uses dry ice as a propelling agent. A dry ice "pencil" is said to remove warts. An ice-skating act uses it to quick-freeze a portable rink. The "rainmakers" use dry ice. Toy airplane engines and other devices are driven by dry ice.

Hollywood uses it to make "fog" and "mist," to make drinks bubble like champagne and to show reaction in beakers and other equipment when a scientific laboratory scene is required.

Dry ice is used in cautery and surgery. It is used to freeze broken water mains on each side of the break to stop the flow of water long enough to make repairs. It has been used to freeze quicksand to assist in building operations.

➤ "Use *no ice picks*" *says the caution on the lid of this modern refrigerated shipping case. Chips of dry ice would burn the skin if they should fall on the hands of the packers, but containers are designed to do their job neatly and safely.*

Dry ice is used in the manufacture of golf balls, neon tubes, radio parts and in the testing of radio crystals. Crepe rubber, difficult to handle in its normal state, is easily cut to the proper size after being frozen with dry ice.

Its uses go on and on. Like the bubbles in your drink they seem endless. Aladdin had nothing on modern man. He rubbed a magic lamp and produced a vapor which evolved into two jinn who could do for him anything he desired.

We have carbon dioxide.

For The Home Lab

Hydrogen Peroxide

by Burton L. Hawk

➤ This month, let's become better acquainted with an old friend—the familiar "peroxide" from the medicine cabinet. We've used it on cuts and sores, we've gargled with it for sore throat, and (horrors!) perhaps we've even bleached our hair with it.

The ordinary drug store variety contains only 3% hydrogen peroxide. The remaining 97% is printed on the label as an "inert ingredient": in other words, water. The chemist uses a 30% solution. During World War II, the Germans had prepared an 80% hydrogen peroxide which they reacted with sodium permanganate. The resultant mixture of steam and oxygen generated was used to drive the fuel pumps of the V-2 rockets. In this country, hydrogen peroxide of 95% purity has been produced.

The chief asset of hydrogen peroxide is its ability to oxidize readily. The higher concentrated variety is an exceedingly powerful oxidizing agent. It will ignite wooden splinters and fragments of cloth upon contact. Although it is fairly stable and will withstand shock, a slight trace of an organic compound will render it highly explosive. This does not seem at all similar to the medicine cabinet "peroxide," but it is the same compound, only more of it.

Preparation

Because it is inexpensive and easily obtainable, it is not practical to prepare hydrogen peroxide for home use. We include this instruction only for demonstration purposes.

Hydrogen peroxide is obtained by the inter-action of an acid with a peroxide. Barium peroxide is usually used. Place a small quantity of it in an evaporating dish and mix into a smooth paste with cold water. Then add a cold dilute solution of sulfuric or phosphoric acid and stir. When all action ceases, filter off the barium sulfate or phosphate to obtain hydrogen peroxide in the filtrate.

$$BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$$

Add a little of your hydrogen peroxide to potassium permanganate solution. The red solution will turn colorless with effervescence.

Oxygen

Hydrogen peroxide decomposes into water and oxygen. The action is hastened by heat and light. This explains why it is always sold in amber colored bottles and should be kept in a cool place. Sometimes acetanilid is added to commercial solutions in order to retard decomposition.

Manganese dioxide will accelerate decomposition. To 5 cc. of hydrogen peroxide (3% variety) in a large test tube, add a small quantity of finely powdered manganese dioxide. The reaction will be moderately vigorous as oxygen is evolved. You can test for the latter by inserting a glowing splinter into the tube. The concentra-

tion of oxygen will cause the splinter to glow brighter or burst into flames.

Oxidation

Black to White. Hydrogen peroxide will oxidize black lead sulfide to white lead sulfate:

$$PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$$

Prepare lead sulfide by mixing dilute solutions of lead nitrate and sodium sulfide. Then add hydrogen peroxide to transform black to white. This reaction is utilized in the restoration of old oil paintings which have darkened due to action of sulfides on the lead pigments in the paint.

White to Black. Hydrogen peroxide will oxidize white manganous hydroxide to black manganese dioxide:

$$Mn(OH)_2 + H_2O_2 \rightarrow MnO_2 + 2H_2O$$

Prepare manganous hydroxide by mixing dilute solutions of manganous sulfate and sodium hydroxide. Then add hydrogen peroxide to transform white to black.

Light Blue to Dark Blue. Mix together very dilute solutions of ferrous sulfate and potassium (or sodium) ferrocyanide to form a lovely light blue solution. The addition of hydrogen peroxide will immediately change the color to dark blue. In this case the ferrous ion has been oxidized to ferric.

Colorless to Brown. Hydrogen peroxide will liberate iodine from iodides. Add a small quantity to a solution of potassium (or sodium) iodide. Immediately the colorless liquid turns brown as iodine is liberated and dissolves in the iodide solution.

Tests

There are many tests available to determine the presence of hydrogen peroxide. We will present only a few of the better known.

1. A pink solution of potassium permanganate is turned colorless by hydrogen peroxide.

2. Add a few drops of sulfuric acid to a solution of potassium dichromate. Upon the addition of hydrogen peroxide, a bright blue compound is formed which gradually turns to green. The actual composition of this blue compound is uncertain; it is probably perchromic acid.

3. Add a few drops of citric acid solution to a solution of ammonium molybdate. Hydrogen peroxide forms a yellow color with this mixture.

Uses

Industrially, hydrogen peroxide is used chiefly as a bleaching agent of such substances as hair, silk, straw, ivory, feathers, bone, gelatin, flour, etc.

Chemically, as illustrated above, it is used as an oxidizing agent.

Medically, it has long been used as a germicidal agent and antiseptic. We hesitate to betray an old friend, but we must report that recent bacteriological tests have questioned its efficiency in this respect.

Phosphorus burns are treated successfully with a solution of 1% permanganate of potash and 3% bicarbonate of soda, it is reported.

Rubber molds are being used in England to cast statuettes of tin, white metal, and lead; over 300 castings can be made from one mold, it is claimed.

Paper Waste Raw Material Gives Better Synthetic Rubber

Rubber From Paper Waste

➤ RAW material for tomorrow's synthetic rubber can be obtained from waste from the manufacture of paper from spruce wood, the American Chemical Society was told.

This rubber-making chemical is called PADMS, which is short for para alpha dimethyl styrene. It can replace the usual styrene that combines with butadiene to make GR-S synthetic rubber, the sort now in largest production. Dr. K. A. Kobe and Dr. R. T. Romans of the University of Texas made the report to the chemists.

Now styrene is in very short supply because of the expanded synthetic rubber program and because it is widely used in new synthetic chemical processes. It is made from benzene, obtained from oil or natural gas, and this is the mother material of so many other essential chemical products.

From the by-product of sulfite paper pulp, which is not only waste but a nuisance, chemists can obtain para-cymene which is then converted into PADMS by a process known as catalytic dehydrogenation.

The synthetic rubber made with the kind of styrene from paper manufacture may even produce better synthetic rubber than the styrene now used. A few experimental batches of synthetic rubber were made with PADMS produced from terpenes by the turpentine or naval stores industry. In the few tires tested, there was a hint that the rubber might be superior to the kind now manufactured, but much larger pilot plant manufacture and extensive road tests of the tires made will be necessary before the scientists can be sure. There is confidence that the new rubber will be just as good as the present synthetic sort.

The paper pulp industry is expected to be willing to install the necessary recovery equipment for the cymene by-product if it would be utilized in large amount by the synthetic rubber industry. And the synthetic rubber plants would be reluctant to convert to the paper pulp raw material unless large supplies were assured.

Synthetic rubber production of the GR-S variety is now above the 400,000-ton-per-year mark due to the war situation and it is expected to increase in coming months.

Bituminous shale in the Lonquimay region of Chile is said to yield over 100 quarts of oil per ton; a company has been organized to develop the deposits to obtain gasoline for Chilean motor vehicles.

Mono and di-ammonium phosphates are excellent chemicals for fireproofing wood; when the wood is properly impregnated they stop flame and after-glow, have little corrosive effects on metals and are not hydroscopic.

Cost of Production Determines Ore Value

Iron Ore For America's Furnaces

by M. D. HARBAUGH

Vice-President and Secretary of The Lake Superior Iron Ore Association

Extracts from an address given at the Cleveland Meeting of the American Association for the Advancement of Science, Dec. 27, 1950.

➤ WITH THE DISCOVERY of high-grade iron bearing deposits in the Lake Superior region over a hundred years ago, and the development of the Bessemer converter a few years later, began the real age of steel in America. The opening of the great Mesaba Range in the last decade of the 19th century was of the utmost significance in bringing our country to preeminence in steel production and industrial power in the world.

Before proceeding, it may be pertinent to consider briefly the question: "What is iron ore?" The answer depends upon where you are, when you raise the question and how much you need. In general, iron ore is a mineral deposit containing enough iron and not too much of other elements, so that it can be used at a given time and place for producing iron in commercial quantities. Its value as ore depends upon the cost of creating and operating facilities to mine, transport and smelt it, in comparison with the value of the metal produced and delivered to the places where it can be used. The deposit can be called "ore" only when its production is profitable in the light of these considerations. Thus, even a large and readily minable deposit, high in iron content and low in impurities, may be only potential ore at that place and time, whereas in some other place or time, a much leaner grade of iron-bearing rock may be usable ore because of its easy access, availability to fuel and to markets for iron and steel. Changes in costs and prices, in transportation, in the technology of production or utilization, in labor, power supply or other factors, may make ore of what previously was not ore; and by the same token, other economic changes, cheaper competive sources of supply, or even burdensome taxes, may eliminate ores without changing their physical form one iota.

The processes of geology created the iron-bearing rocks, and sometimes altered them subsequently, to become the ores which we mine. Other geologic processes also may have been significant factors in making usable ores out of the material which Nature provided. The Lake Superior ores, most of which contain more than 50% iron, might still be relatively undeveloped and unused had not Nature provided also the Great Lakes, as a sort of geologic "after-thought", to permit cheap transportation to the places where fuel is available and where the iron can best be utilized. In Alabama, the principal ores, which

contain only 35% iron and too much phosphorus and silica to be pleasing, also might not be very useful except that fuel and fluxing stone are available practically in the same spot, so that the cost of producing iron from these raw materials is low by comparison with iron available from elsewhere.

Thus, it is evident that economics and geology are inseparable factors in the creation of ores—whether of iron or of other elements.

Geology of Iron Ores

As to the geology of iron ores, it is interesting to note that most of the great deposits throughout the world—including those of the Lake Superior district, Labrador, Venezuela, Brazil, India, and some others—are parts of vast ancient sedimentary formations—marine precipitates of silica and iron in various mineral forms—commonly classified as ferruginous cherts. Most of them are in the ancient groups of rocks we lump together as "pre-Cambrian", evidence that for some reason iron was being contributed to the seas of those times in greater volume than in later eras.

In the Lake Superior district, with minor exceptions the iron formations —which have different names in the several mining areas, despite the fact that some of them may be essentially the same stratigraphic horizons—are several hundred feet in thickness, part of the extensive series of so-called Huronian sediments. These bedded rocks were folded and faulted, intruded in various ways by igneous matter, elevated into mountains and then eroded to low elevations. In part they were buried by much later sediments which have been eroded wholly or partly. In the roots of those ancient mountains, we find the iron formations—warped, wrinkled and upturned. The glaciation—last notable geologic event in this region—left a concealing mantle of drift, sometimes 200 or 300 feet thick, and many lakes covering these old rocks. Through this cover the search for ore must be made; removal of this overburden is one of the major tasks of the mining operations.

The term "range" is applied to the near surface exposure of the cross section of the iron formation—usually a linear geologic feature—in any given area of the Lake Superior region. Thus, the Mesaba range of Minnesota is the beveled edge of the Biwabik iron formation—extending over a hundred miles, nearly east-west, and dipping gently toward the south beneath overlying slates and other bedded rocks. The ores which are now being mined are natural concentrations within the iron formations in places where geologic conditions permitted ground waters easiest access, in order to remove and transport silica and to oxidize and stabilize the iron minerals. These concentrations of iron minerals within the iron formation are analogous to the plums in a pudding. We have been finding and using the plums, but soon we must also use the best parts of the pudding.

In Alabama, the iron ores are also bedded sedimentary rocks, but of much lesser thickness, different in origin and composition. In the Eastern states and in the West, and in southeast Missouri as well, the principal ores are wholly different in origin and type from those above described, being directly related to ig-

neous intrusives. They are contact, replacement, or vein deposits, similar to many deposits of other ores throughout the world.

The Lake Superior district at present produces more than 81% of the nation's output. The proportion of the total U.S. furnace requirements supplied from there, however, is less than that, because of increasing volumes from eastern and western mines as well as of imports. It is significant that the imports have risen very substantially in recent years, a trend that is destined to be much accelerated in the near future.

"Inexhaustible" Resources

Prior to World War II, there was no concern about the future supplies of iron ore for America's furnaces. In fact, some people in the industry thought we were settling down to an era in which returning iron and steel scrap would supply such an increasing volume of feed to our furnaces that Lake Superior ore producers would be hard pressed to retain their normal market volume—50 million tons or so. The war, and the expanding economy of the years since, of course have shown the fallacy of any such assumption. I cite it merely to illustrate the common difficulty of trying to see ahead.

The inroads upon the Lake Superior ore reserves caused by shipments of 787 million tons during the last decade—of which the Mesaba range supplied nearly 600 million—rapidly changed a position of complacency to one of concern about our domestic ore supplies for the long future, and made clear that the known and probable reserves of commercial grade ores would by no means last indefinitely. Hence, the question arose—"what about the future supplies of iron ore for America's furnaces?", which is really our topic.

As to the ore supplies for southern and western furnaces, from the states indicated as Southern and Western, suffice it to say that the tonnages locally available appear to be wholly adequate for the local requirements a very long time to come. However, the important Alabama red ores which occur in great volume, well over a billion tons according to reliable estimates cannot be considered as a potential reserve for the furnaces now dependent on Lake Superior ores, as they are too far away, too low in iron content and too high in impurities to be adapted to the requirements of the latter plants. Besides, for the most part, they must be mined underground rather than in open pits, which precludes the flexibility in productive capacity so essential to meet emergency demands. Furthermore, beneficiation to remove silica is indicated as essential to make economically usable a large part of these Alabama reserves.

Steel capacity and production in the South and particularly in the West, have been substantially expanded in the past decade, and there is no doubt that gradual further expansion is to be anticipated to help meet the increasing needs of the expanding population and industrial growth in those parts of our country. And although local ores long may be expected to meet the principal future requirements of these areas, future imports at Gulf ports and possibly on the west coast eventually may play an important part in southern and west-

ern steel production that is not now apparent.

Blast furnaces in eastern Pennsylvania and Maryland, and one in Massachusetts, normally are supplied in part from the output of the eastern iron ore mines, in northern New York, eastern Pennsylvania and New Jeresy, and in part from imports from over-seas. In wartime, however, the imports have had to be replaced by domestic shipments mainly from the Lake Superior district, so in reality Lake Superior producers, with help from the eastern producers, have borne the responsibility for supplying most of our domestic requirements outside the South and West.

Potentialities exist for substantial increases in the reserves and output of eastern ores, especially in the Adirondacks, but whatever these reserves eventually prove to be does not greatly change the situation created by the gradual depletion of presently minable ores of the Lake Superior district. I say *gradual* depletion, to make clear that it is not as alarming as some publicity has indicated. A brief review of the Lake Superior record will reveal what I mean and will show the fallacy of estimating the remaining life of the district as a whole, or of the Mesaba or any other range alone, by simply dividing the actual known reserves of commercial type ores, at a given time, by the current or recent rate of extraction, a practice too frequently indulged in. For example, from 1915 to 1949 while the known taxable reserves declined from 1,689 million to 1,122 million tons, shipments were 1,833 million tons or 3.23 times the amount of the depletion which was 567 million tons. In other words, 1,266 million tons of ore was added to the reserve in 34 years by the combination of continued exploration and development, improved technology in the mining, handling and treatment of ores, together with the changing relationships between costs of production and prices of product. One naturally inquires as to whether such a ratio of additions to depletion of reserve can be anticipated in the future; and the answer is "no", certainly not, of the types of ores we have been accustomed to producing. No great new iron ore "ranges" comparable to the Mesaba are likely to be discovered. But the record of new ores developed to offset shipments in even the past few years is sufficient to give assurance that one still does not find the answer by dividing the present known taxable reserve of near 1,200 million tons by approximately 80 million annual output to determine "how long" the reserve will last. Since January 1942, tonnage added exceeds 30% of the reserve known at that time, whereas some predictions had indicated 10% as the likely maximum.

Productive Capacity

It is of utmost importance to keep in mind that "annual productive capacity" of the mines is the consideration of greatest concern to the industry—both consumers and producers—rather than the possible over-all tonnage eventually to be mined over the next half century or so. In the face of a growing population and continuous improvement in living standards—which means more steel per capita—combined now with national emergency requirements for greatly expanding steel capacity and output,

the problems of ore supply are reduced to realistic questions for which answers must be provided in terms of tonnages available for delivery to furnaces in 1951 and in each year thereafter, for as long as it is feasible to anticipate.

The iron ore industry and the steel industry of which it is part, have been fully alive to their responsibility for maintaining adequate available supplies of ore to meet any possible annual demands. They have been doing something about it, some of them even before the need became so apparent early in World War II. Since the war, their efforts toward increasing the available supplies have been greatly accelerated. It is needless to recite the various steps taken that now give assurance of adequate supplies of ore for America's furnaces for the indefinitely long future. Three important new sources are in the offing, with developments advancing so rapidly that substantial tonnages from these are expected to be available by the time they may be needed —within the next five years.

Magnetic Taconite

First, and of most importance from the standpoint of national security, is the program for concentrating the natural iron formations of the Lake Superior ranges, particularly the magnetic "taconite", so-called, of the Mesaba range. Every large company operating in the Lake Superior district has been for some years active on this project, with extensive laboratory research and field studies preliminary to commercial operations. From these magnetic iron-bearing rocks—containing 20% to 30% or more iron—furnace feed containing 60% to 65% iron, and no moisture, can be produced by a combination of practical beneficiation processes. The manufactured ores are superior to the natural ores. They are expected to be competitive in cost, delivered at furnaces, with ores now being developed in other lands for importation into this country as additional major sources of supply. In the Lake Superior ranges, there are also non-magnetic types of iron formation, far greater in volume than the magnetic types, from which, by other methods, desirable furnace feed is expected to be produced. Together, the vast tonnages of these iron-bearing rocks—measured in billions—constitute a reserve of almost inconceivable magnitude. The extent to which this reserve contributes ultimately to our metal supply, depends upon the economic stability or instability of the world about us and upon competitive conditions affecting production of usable ore from it, as compared to production from the vast new high grade supplies being developed in the Labrador peninsula, in Venezuela and elsewhere. Nevertheless, these Lake Superior iron formations must always constitute the backbone of our "defense reserve", since they lie within our national borders and are accessible by traditional transportation facilities to the principal ore consuming districts. One vital lesson driven home by World War II, was that we must never allow our country to become dependent to a large extent on overseas supplies of iron ore. The next decade appears certain to see commercial production of ore from taconite or similar formations reach-

ing a volume of several million tons annually, and expanding rapidly thereafter.

Second, along with all the work being done on taconite concentration, important exploration which may lead to new discoveries of high grade ores has been under way in the Lake Superior district, on both sides of the international border. Extensive magnetic surveys by air and detailed geologic studies in promising areas, have been carried on by State and Federal agencies, and much exploratory drilling, both from surface and deep underground, and other geological work has been under way by the mining industry. In the Steep Rock and Michipicoten areas in Canada, which now produce significant tonnages of excellent ore that moves into the stream of supply from the Lake Superior district, available supplies ultimately may be far greater than has been indicated to date. Discoveries in other Canadian areas may well be anticipated. The extent to which the Canadian sources further supplement our domestic output from the Lake Superior district is important, for the United States and Canada are essentially a unit in supplying their joint requirements of ore.

Nine large new ore-carrying vessels, costing at least five million dollars each, are to be built in the next two years to meet the added transportation requirements on the Great Lakes, evidence in itself that the Lake Superior iron ore industry isn't on the way out. Millions of dollars are to be spent for additional blast furnaces and new steel capacity to be constructed at lower lakes plants now dependent on Lake Superior ore, to meet the needs for more iron and steel in the immediate future.

Lake Superior ore producers are preparing to meet whatever emergency demands may be imposed upon them in the next few years, even to supplying the needs of a major war, if that is what must be anticipated.

Third and most spectacular, in magnitude as well as in the romance of discovery and engineering, are the new iron ore enterprises under way in Labrador-Quebec, in Venezuela and in Liberia, all to produce very high grade ores. Great deposits in the Labrador peninsula, far north of the St. Lawrence River, are under intensive development by combined American and Canadian interests, with five American steel companies participating. Production is expected to get under way within less than five years, to reach 10 million tons annually soon thereafter. Much larger output is anticipated later when needed. This ore must move by rail, over a line now being built, 360 miles to a St. Lawrence port, thence by water, or water and rail, to consuming districts. When the St. Lawrence Seaway is built, it will move into lower lake ports, the same as Lake Superior ore. Some of it doubtless will move also to Atlantic ports.

Venezuela

Venezuela is destined to play an important role in the future ore supply for America's furnaces. Bethlehem Steel Company, which for some years has been developing important high grade deposits there, started shipments to its Sparrows Point plant on Chesapeake Bay this fall, and its production is expected to reach about three million tons annually. The other

important current development in Venezuela is that of the United States Steel Corporation, at Cerro Bolivar—where a newly discovered, tremendous deposit of high grade ore is available. Most of you certainly have read about this spectacular find. Within the next three or four years, when rail and water transportation facilities are constructed, shipments from this area will begin and are expected to reach 10 million tons annually, and as much more as may be needed. Part of it will supply new steel making facilities to be built on the eastern seaboard; part of it will move inland to furnaces in the Pittsburgh district; and some may go to Gulf ports for use in southern furnaces.

Republic Steel Corporation is preparing to start shipments, probably in 1951, from the important deposit of very high grade ore it has been developing in the jungles of Liberia, for which rail and vessel transportation and handling faclities are now in process of completion.

Thus, iron ore in great abundance is being made ready to supply America's furnaces—not only for the existing plants and additions thereto but for others yet to be built—and for a period as long as seems feasible to contemplate. Those who had fears about the iron ore supply can forget them. The Lake Superior district can be expected to continue as our domestic mainstay, our defense reserve, regardless of the conditions in the world outside our national borders. Furnace feed made by concentrating taconite and the other iron formations will extend the life of the natural high grade ores almost indefinitely, and the new supplies of ore from Labrador, South America and Africa will supplement the Lake Superior output in any volume necessary to preclude a possible shortage of ore, no matter what the annual demand may be. The forces of competition will determine — except in times of national emergency—the share of the market that each of these several sources will supply.

Strategic Mineral Production Urged

➤ Increased production of domestic minerals is being urged by the government to meet growing demands for strategic and critical metals and other minerals, according to Dr. James Boyd, head of the U. S. Bureau of Mines.

The minerals for which step-up programs in production are most needed at the present time include antimony, asbestos, beryllium, chromite, cobalt, columbium-tantalum, copper, fluorspar, graphite, sulfur, talc, tungsten, zinc, molybdenum, nickel and platinum.

To assure increased production, the Secretary of the Interior, Oscar L. Chapman, has created a Defense Minerals Administration with Dr. Boyd as its chief.

The Defense Minerals Administration is the prime point of government contact with the minerals industries and the manufacturers of mining machinery and equipment. Under the Defense Production Act of Congress, assistance can be given by the government to mineral producers unable to expand production otherwise.

Highlights from Annual Meeting of American Institute of Chemical Engineers

Advances in Chemical Engineering

A variety of subjects was discussed at the 43rd annual meeting of the American Institute of Chemical Engineering at Columbus, O., early in December.

Purifying Cooking Oil

➤ Lower cost cooking oil may result from studies by two Iowa State College chemical engineers who found that solvent-extracted soybean oil can be purified more efficiently by using stripping columns packed with rolled spiral weave conveyor belting material.

Soybean oil, used on a large scale in salad and cooking oil, vegetable shortening and margarine, is mostly produced by extracting it from the beans with a solvent which must then be removed to produce a pure edible oil. This is done by blowing steam through the oil-solvent mixture which is passed through a tower packed with materials that will help expose as much of the oil as possible to the steam. The fewer passes and the less steam required to make pure oil, the cheaper the oil will be. The new packing material developed by Drs. Arnold and Ingebo promises to double the capacity of solvent-stripping plants, cut the steam consumption in half, and produce a very pure oil.

The report was presented by Dr. L. K. Arnold and Dr. R. D. Ingebo of Iowa State College. Dr. Arnold is professor of chemical engineering, and Dr. Ingebo, formerly research assistant, is now a research engineer at the Cleveland laboratory of the National Advisory Committee for Aeronautics.

Air Safe From Radioactivity

➤ Decontamination techniques perfected by engineers of the Atomic Energy Commission have successfully eliminated the possibility of atmosphere pollution by radioactive airborne wastes from atomic reactors.

W. K. Eister and W. G. Stockdale, from the Oak Ridge National Laboratory, Oak Ridge, Tennessee, reported two methods are used to eliminate radioactive wastes which reduce radioactivity to the level normally present in the atmosphere. For those few radioisotopes which are true gases, more complex absorption procedures are required.

The cost of both techniques is high, and a present trend has been to reduce the volume of air that may become contaminated. In the past large quantities of air have been used to ventilate areas in which high levels of radioactivity were expected. This increased heating and air-conditioning costs money, and the trend is toward the greater use of air-tight equipment.

The radioactivity that is removed from the air must be permanently stored, as it will be years, in most cases, before the radioisotopes have decayed to their stable products. In some cases, however, where work with short-lived radioisotopes is carried out,

storage for about one hundred days is all that would be required.

Black Glass Heats House

➤ BLACK GLASS can be used to heat houses by capturing radiation from the sun, which supplies the United States with energy equivalent to over 150 million tons of coal every day. Most of this energy is wasted at present, but could be captured for residential heating, according to a report presented by Everett R. Irish, now a chemical engineer with the General Electric Company at Hanford, Wash., and Dr. George O. G. Löf, professor of chemical engineering and director of the Industrial Research Institute at the University of Denver.

The heat collector consists of a group of partially blackened, overlapping glass plates, mounted on a house roof. The arrangement is similar to that of shingles, separated by small air spaces. A glass cover over the staggered plates is employed to keep out dirt.

Because of the high transmissivity of glass for solar radiation, and its low transmissivity for long-wave heat radiation, the black or clear glass surfaces in the unit become heated when exposed to the sunlight, and the reradiated heat has no avenue of escape. Air passing between the plates is heated from the trapped heat of the sun and forced into the house.

A roof-top solar heat installation can already be designed to supply 60% of the energy required for heating a home.

Dust and Odors of Industry

➤ CHEMICAL MANUFACTURERS should bend over backwards in their efforts not to permit the discharge of obnoxious or dangerous amounts of pollutants into the atmosphere. However, the public must accept the fact that, since they live in an industrial community, they cannot expect an odorless, dust-free atmosphere. This was the opinion of Marcus Sittenfield, consulting chemical engineer of Philadelphia.

It is unfortunate that there are few sound definitions of what is a "reasonable" amount of contamination as stated in the legal codes, he said. Each case must be settled substantially on its own merits. No compromise can be made if a plant is discharging gaseous materials that are of sufficient concentration to be toxic or that result in property damage.

The best assurance the public can receive is, of course, that equipment be installed to remove substantially all odorous and corrosive materials from waste gas discharges. To do this requires a careful and thorough study of all the analytical problems that are involved.

Methods for control of air pollution include disposal through stacks, meteorological control, use of filtration, sedimentation, scrubbing, adsorption, and incineration equipment. The selection of the proper equipment is based on experience combined with the application of chemical engineering principles of mass transfer, fluid flow, and materials handling.

Glass Conducts Electricity

➤ GLASS THAT conducts electricity, described by A. H. Baker and R. A. Miller of the Pittsburgh Plate Glass Company, is used in windows of airplanes, locomotives and ships, to help keep the windows free of fog and ice.

Very lightweight glass, full of tiny

bubbles, is another unusual product, which is proving itself as a fire-proof insulating material and a buoyant core for life rafts. Glass blocks have by now invaded every type of construction, from residences to chemical plants.

Toluene and Benzene Process

➤ MORE ESSENTIAL chemicals for defense are promised by a new process for manufacture of toluene and benzene.

The shortage of these important materials for explosives and synthetic rubber manufacture may be alleviated by a new catalytic process which converts certain aromatic hydrocarbons that are abundant in some petroleum oils into either toluene or benzene. A report by Dr. Lloyd Berg and co-workers of Montana State College, Bozeman, Montana, described the use of a catalyst consisting of alumina pellets treated with hydrogen fluoride, which "triggers" the wanted reactions.

Complex compounds in gaseous form when passed over these pellets at high temperature are stripped of the undesirable constituent. The resulting products are distilled, yielding the benzene and toluene fractions.

Eventual production in fluidizing units is predicted. Equipment of this type is now in use in the United States for manufacturing large volumes of high octane gasoline.

Sulfur Salvaged From Petroleum

➤ SULFUR and natural gas, obtained as by-products in petroleum production in the new oil field at Worland, Wyoming, are not wasted as formerly but are salvaged and are expected to yield a profit of $2,500,000 a year.

Natural gas produced with the crude oil in this area has a high hydrogen sulfide content which makes it extremely poisonous. The sulfide content is the highest yet found in any oil field gases. A similar gas at Elk Basin, Wyo., has an average content of hydrogen sulfide of 20%, but the Worland field has a 33% sulfide content.

Just completed between Worland and Baker, Mont., is a 13-inch pipe line approximately 340 miles long. Also constructed is a sulfur extraction plant, a gasoline plant and a compressor station. Funds for the construction, some $15,000,000, were provided by the Pure Oil Company, The Texas Gulf Sulphur Company and the Montana and Wyoming Pipe Line Company.

The gas is first put through the sulfur extraction and casinghead gasoline plants where an average of 300 tons of pure sulfur and 30,000 gallons of liquid products are obtained each day. Some 15,000,000 cubic feet of practically sulfur-free gas are obtained which is suitable for domestic uses. However, before distribution it is mixed with sweet gas from an upper gas formation.

At first the poisonous gas and recoverable natural gasoline in this field were conducted by pipe high in the air and burned. The new pipe line makes it possible to gather the production of the fields into a central plant large enough to warrant the cost of salvaging both sulfur and gas.

Chemical Patents

Copies of complete specifications may be ordered from the Commissioner of Patents, U.S. Patent Office, Washington 25, D.C. Order by patent number and remit 25 cents for each patent, by money order or Patent Office coupon, not stamps.

Mildew-Resistant Fabrics

➤ TEXTILE FABRICS of fibrous cellulose materials are highly resistant to mildew by a relatively new acid-treatment process on which the government has issued a patent.

Cellulose materials, including common textile fabrics, are subject to attack by fungi which cause the deterioration known as mildew. Several types of mildew-preventing treatments are in use. This new one is claimed to be unusually effective.

The inventors of the process, Florence M. Ford and William P. Hall, Wilmington, Del., discovered that if acid is chemically combined with cellulose in the dry state to produce an acid-cellulose complex, the fabric is rendered mildew resistant. Also the finish is durable to water and will withstand weathering for long periods. The finish does not interfere with other finishes, such as waterproofing, nor does it interfere with dyeing.

The chemicals used are phosphoric acid and urea. The quantity required is small. After immersion in the solution, the fabric is dried, and then baked or cured at temperatures ranging from 300 to 400 degrees Fahrenheit. The patent is 2,524,783. Rights have been assigned to Joseph Bancroft & Sons, of Wilmington.

Sugar Without Molasses

➤ MANUFACTURING white sugar without molasses as a by-product is promised by a process for which John Paul Bartz, Fort Lauderdale, Fla., was awarded patent 2,526,111. The sugar may be made from juices of sugar cane, sugar beets and citrus fruits. The product is claimed to have superior sweetening and improved nutritional properties as well as reduced fattening qualities.

The process includes the treatment of sugar-bearing fluids and juices by chemical and ion exchange methods. These remove salts present in the liquids and the excess of undesirable gums, pectins, dextrins and proteins. Coloring matter is removed by activated charcoal or bone char. The aqueous sugar solution is then concentrated into crystalline or powdered sugar or into liquid sugar.

Coating for Magnesium

➤ ARTICLES made of magnesium or magnesium alloys may be given a satisfactory metallic coating by a method which brought Herbert K. De Long, Midland, Mich., patent 2,526,544. Rights are assigned to the Dow Chemical Company of the same city. Greatly increased use of magnesium makes the method of particular interest.

Magnesium and its alloys are among the most difficult of all common structural metals to provide with a coating of another metal which will remain in adherence. In this method, the article of magnesium is treated with a solution containing pyrophosphate and zinc. A film of zinc left on the magnesium becomes the base for the retention of other metallic coatings.

Finds Flaws in Rails

➤ GREATER SAFETY in railroad traveling is promised with an improved electrical device to detect invisible flaws in rails.

This device is an improvement over older types because it will detect flaws near rail joints, which others fail to do. Rail joints actuate the mechanism of ordinary detectors of older types. This results in the concealment of flaws within the region affected by the angle bar connector.

The new detector is for use with the Sperry flaw-detector car which is run over the tracks to determine if they are safe for trains. This car energizes the rail by passing a current of electricity through it to create an electromagnetic field around it. The flaw detector explores this field by induction methods to discover any irregularities caused by fissures in the rail.

Patent 2,527,002 was issued to Harcourt C. Drake, Hempstead, N. Y., for this device. Rights have been assigned by him to Sperry Products, Inc., Danbury, Conn.

Cloth Shrinkage Reduced

➤ SHRINKAGE in cotton goods, and shrinkage in wool will be reduced by two separate processes on which unrelated patents have been issued. The treatment for cotton fabrics uses a urea-alkali-zincate solution. In addition to modifying shrinkage characteristics, it eliminates fuzz and makes the cloth stiffer and more translucent.

The inventors of the process are Charles L. Mantell, Manhasset, and Oscar K. Heim, Woodside, N. Y. Rights have been assigned to United Merchants & Manufacturers, Inc., Wilmington, Del.

In the wool-treatment process, a special type of a synthetic basic amino polymer and formaldehyde are employed. The process provides a shrinkproof soft wool fabric, unlike certain other processes which produce a hard material.

Martin E. Cupery, Wilmington, Del., is the inventor. The patent issued to him is 2,526,637. E. I. du Pont de Nemours & Company has acquired patent rights.

Silver Iodide Smoke

➤ A METHOD of generating silver iodide smoke brought Bernard Vonnegut, Alphaus, N.Y., patent 2,527,231. General Electric Company, Schenectady, N. Y., has acquired the rights. Silver iodide smoke is one of the materials employed in experimental work in rainmaking. The more usual material is powdered dry ice, solidified carbon dioxide.

The smoke-making process consists of spraying a solution of silver iodide into a heated zone maintained at a temperature of at least 1500 degrees Centigrade, which is 2732 degrees Fahrenheit.

Air-Pressure Blasting

➤ AN IMPROVED device for blasting coal by air pressure instead of by explosives out of the natural seams in which it occurs brought patent 2,527,291 to Frank H. Armstrong, Chicago, and Edward C. Filstrup, Jr., St. Joseph, Mich. Patent rights are assigned to Armstrong Coalbreak Company, Benton Harbor, Mich.

In this method of breaking down coal faces in mines, a method preferred over ordinary blasting which presents a fire hazard, holes are drilled in the coal as usual. Then air under high pressure is released suddenly in the drill hole, causing rupture to the coal. The improvements in this device include a novel, soft, flexible sealing means to retain the high pressure of the charge and protection of the seal against dust and dirt.

Continuous Casting

➤ THE INCREASINGLY important procedure of casting metals by what is known as continuous casting is responsible for an improved apparatus for the purpose, invented by Norman P. Goss, Mayfield Heights, Ohio. Patent 2,527,545 was awarded to him. His invention includes a novel die open at both ends with means of feeding molten metal into one end, together with means for chilling the metal as it passes through the die so that a continuous bar, rod, billet, strip or slab comes out the other.

Airplane Hazard Lessened

➤ DANGER of disastrous fires in airplanes in flight is lessened with a hydraulic fluid, for operating controls of the craft, which is highly resistant to combustion. This nonflammable hydraulic fluid was awarded patent 2,528,348. Recipients were George H. Denison, Jr., San Rafael, Neal W. Furby, El Cerrito, and Robert O. Bolt, Richmond, Calif. Patent rights have been assigned to the California Research Corporation of San Francisco.

In an airplane the system of pipes that carries hydraulic fluid is widely distributed throughout the craft. Petroleum products are satisfactory as power transmission fluids but they are combustible. Stresses and strains in flight may result in leakage. A nonflammable hydraulic fluid is essential to reduce fire hazard.

This hydraulic fluid contains a chlorinated olefin, such as hexachlorobutadiene, white oil from petroleum and an oil-soluble basic substance to stabilize the mixture against corrosion. The resulting fluid is claimed to have other desirable qualities of a satisfactory hydraulic fluid for airplanes in addition to being nonflammable.

Mica-Coated Pigments

➤ MICA-COATED metallic paint pigments, for use in protective coatings on metals but particularly on zinc, are made by a process which brought Erith Tainton Clayton of Baltimore patent 2,528,034. Rights have been acquired by the Tainton Company of the same city. The process produces metallic powder consisting of metallic flakes having smooth, bright surfaces provided with a thin, hard, permanent coating of mica. The mica is less than five per cent of the weight of the metal. The coating prevents oxidation.

Industrial Award to Chemical Manufacturer

Perkin Medal to Henry Howard

HENRY HOWARD, long prominent in American chemical industry and for twenty-two years chairman of the executive committee of the Manufacturing Chemists' Associatoin, has been selected to receive the 1951 Perkin Medal, highest honor in American industrial chemistry according to an announcement made today by Gustavus J. Esselen, Honorary Chairman of the American Section of the Society of Chemical Industry, which sponsors the award.

Mr. Howard, a native of Jamaica Plain, Boston, Massachusetts, was for 32 years connected in various capacities with the Merrimac Chemical Company, now a part of the Monsanto Chemical Company, and for ten years subsequent to that he was successively Director of New Products Department, Director of Research and Development, and Consultant to the Grasselli Chemical Company, now a part of E. I. duPont de Nemours & Company, Inc. Eighty-nine United States patents have been issued to Mr. Howard, covering principally processes of manufacture of sulfuric and hydrochloric acids, alum and other heavy chemicals, and the specialized equipment required in chemical manufacturing plants.

Mr. Howard's important contributions to American chemical industry included developments connected with sulfuric acid production, the use of Spanish pyrites as a raw material, the development of British Guiana bauxite deposits as chemical raw material and the invention and improvement of instruments and equipment used in chemical manufacture. He was a pioneer in labor relations and wrote the original workmen's compensation law of Massachusetts. Through the Manufacturing Chemists' Association, he was a key person in the development of the American organic chemical industry during and following World War I.

Mr. Howard will receive the 45th impression of the Perkin Medal. It was founded in 1906 in honor of Sir William Perkin, who that year celebrated the fiftieth anniversary of his discovery of the first synthetic dye. He received the first impression of the medal in honor of that event. The choice of the recipient was made by the Perkin Medal Award Committee made up of representatives of the American Chemical Society, The Electrochemical Society, the American Institute of Chemical Engineers and the American Section of the Society of Chemical Industry.

Presentation to Mr. Howard will be made in New York on April 27, 1951. This is a change from the usual custom of awarding the medal in early January each year.

Bituminous coal output per miner per day in America averages over five tons.

What are the Facts?

What is the Hydrogen Bomb?

Where are the Protons and Neutrons in the Nucleus?

How does Electron Structure account for the Elements?

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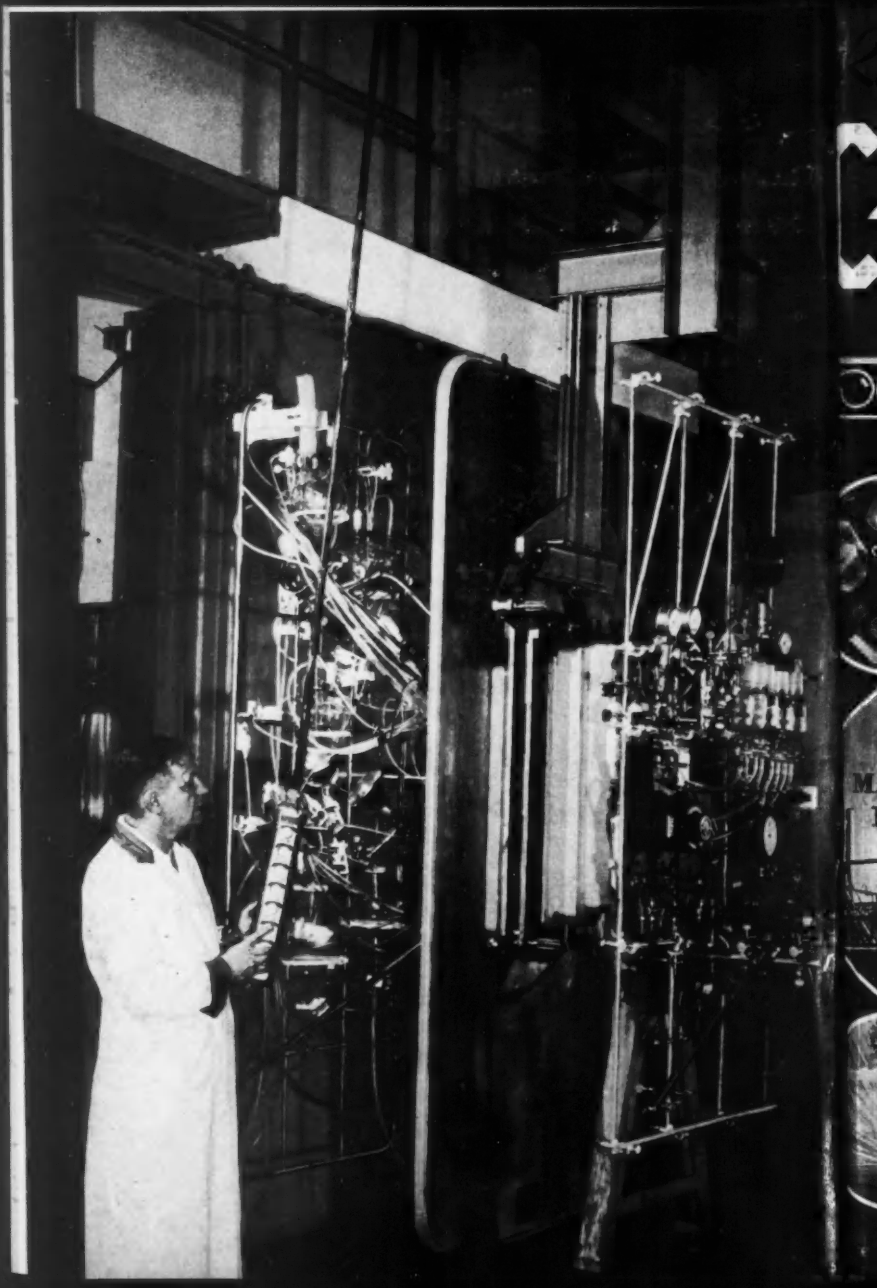
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